VOL. 2 NO. 8

AUGUST 1961

RADIO & ELECTRONIC COMPONENTS

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Technical articles will be gladly considered for publication, payment being made by arrangement. Articles should preferably be from 3,000 to 4,000 words, but no rigid limit is imposed. Manuscripts should be typewritten, in double spacing, on one side of the paper only. Diagrams may be drawn in pencil provided that they are clear and adequately lettered. For half-tone illustrations, glossy prints are preferable. While every care is taken of MSS. submitted, no responsibility can be accepted in case of loss.

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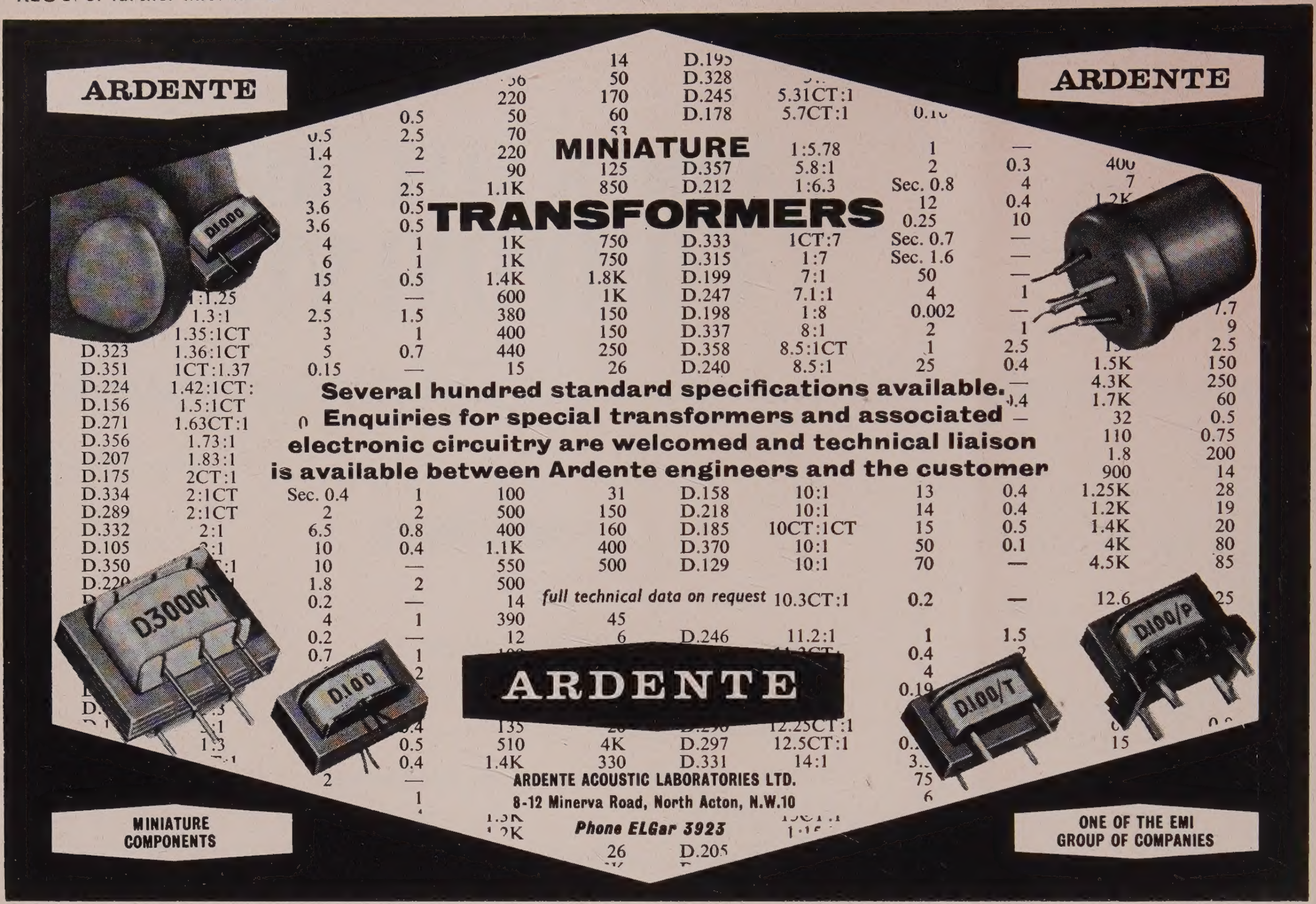

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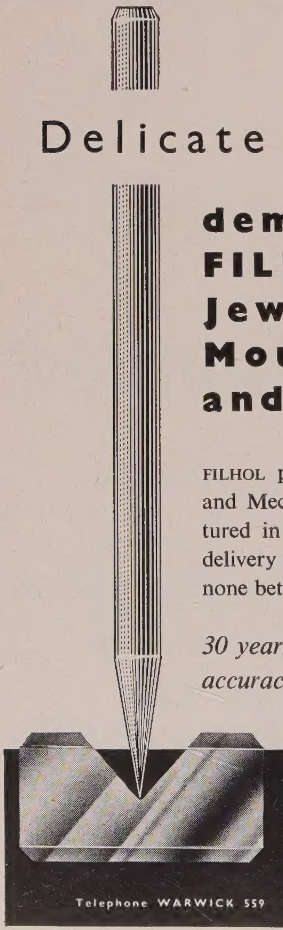

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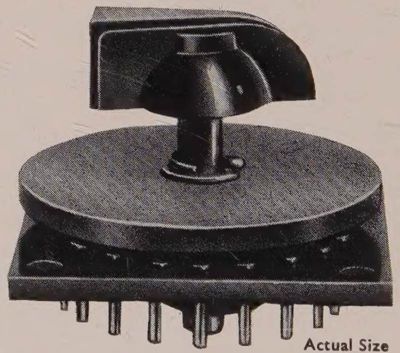

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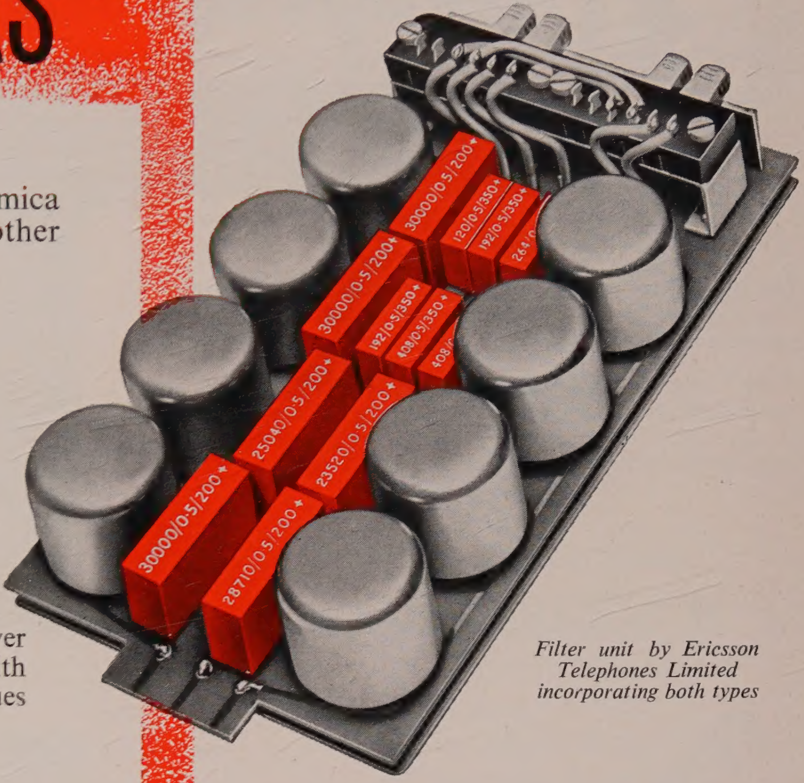

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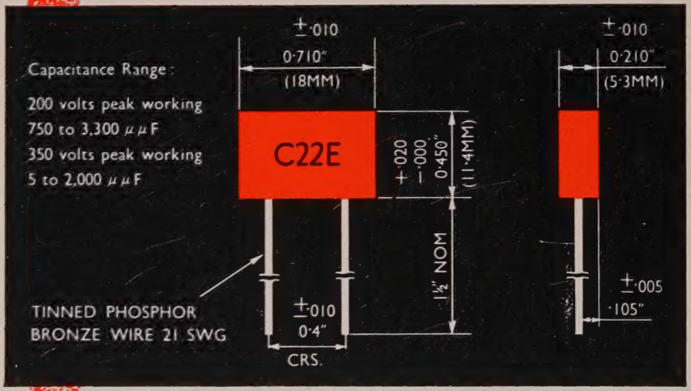
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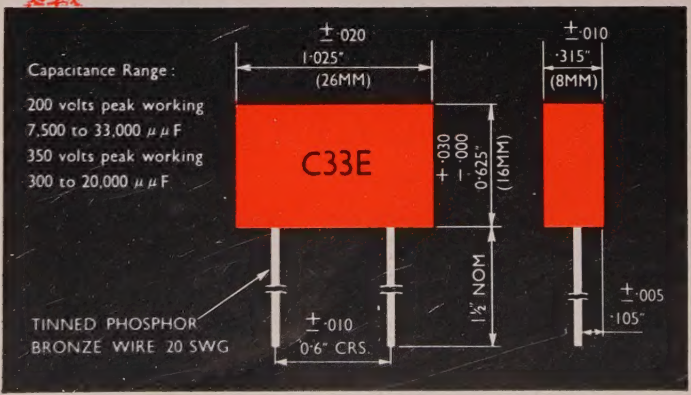
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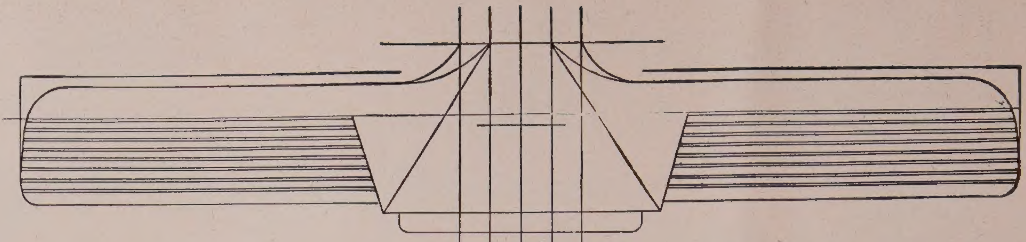

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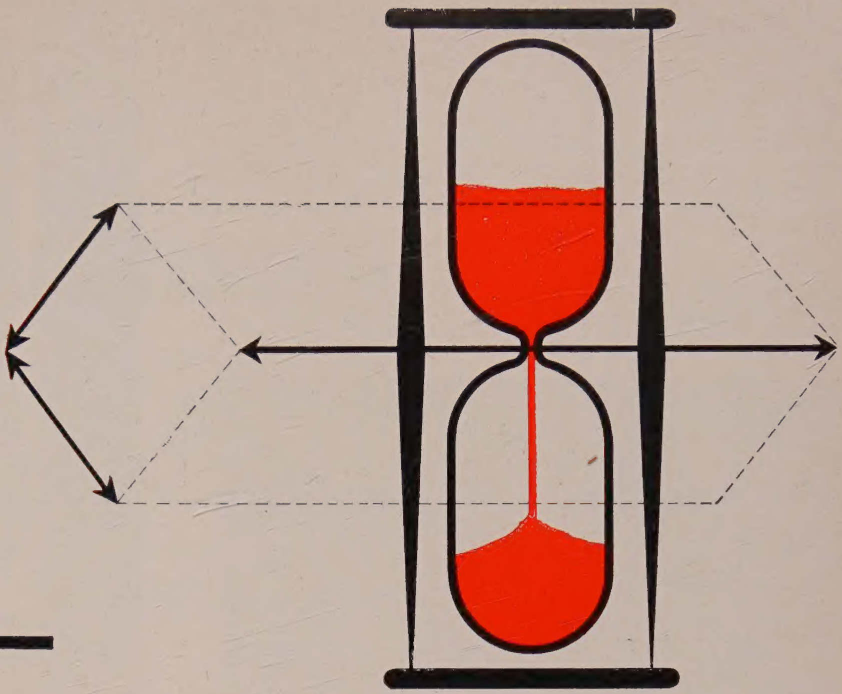

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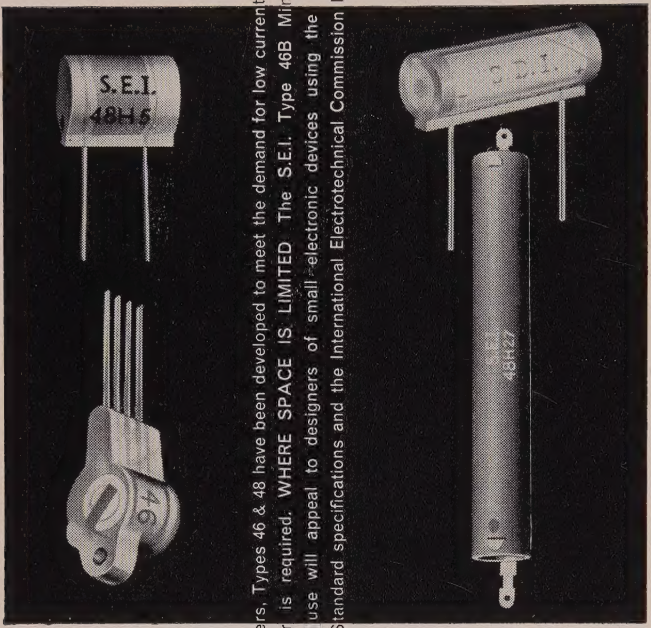

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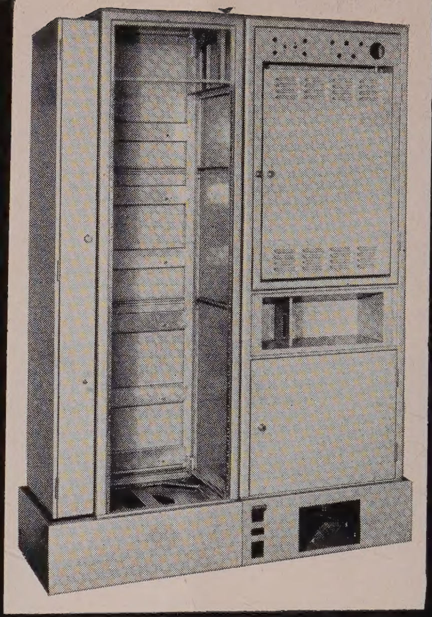

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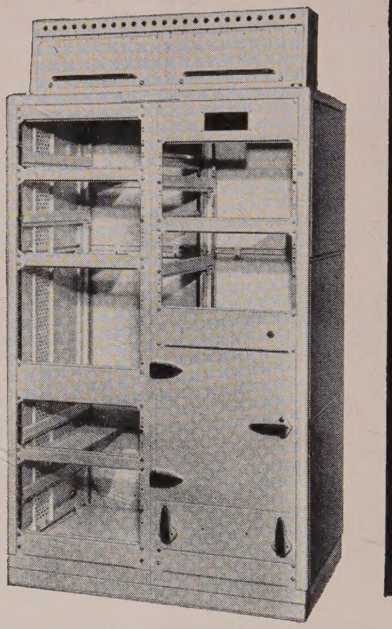

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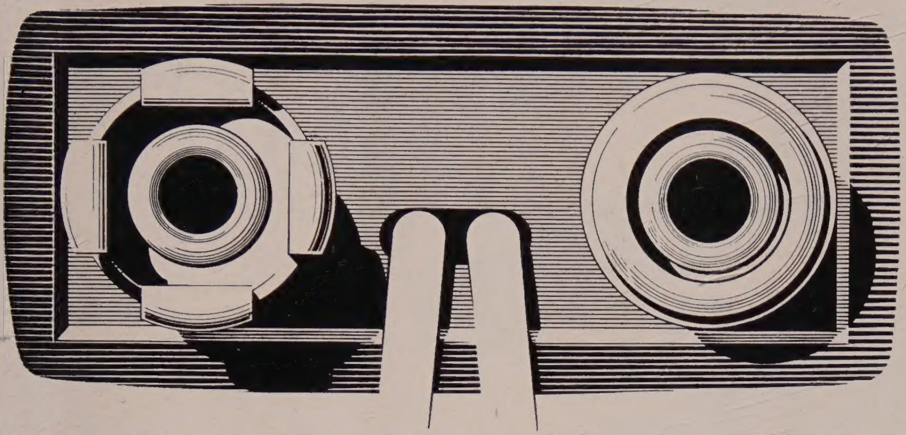
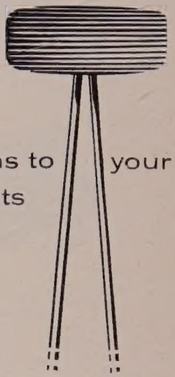
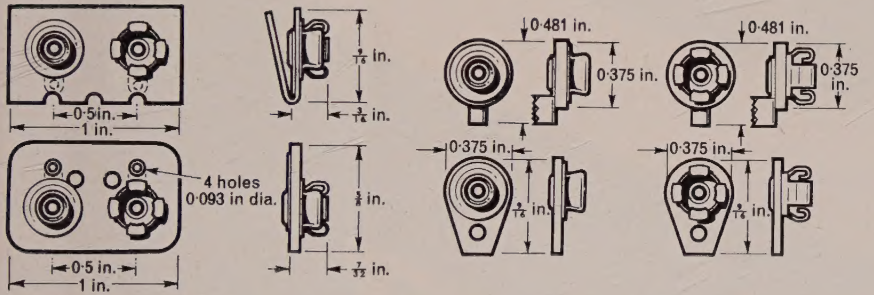
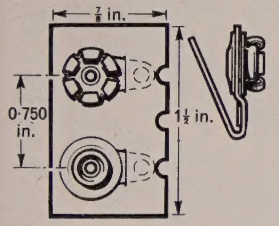


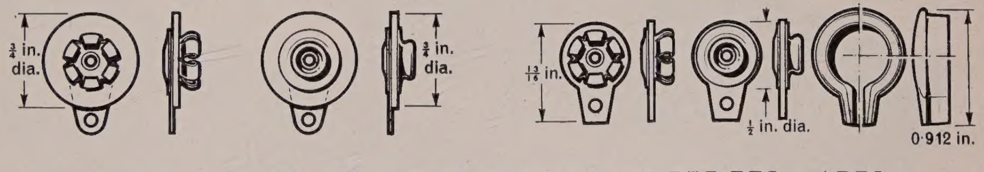


7/8 in. x 13/32 in. x 3/16 in.

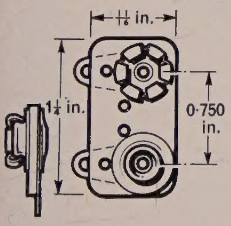
Now in quantity production the new fully insulated, compact snap connector 20/564, suiting batteries B152, PP3, and PP6, is an interesting addition to the comprehensive miniature range. At left are some of the established miniature connectors, and below a few from the standard range.

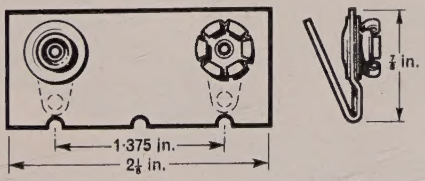




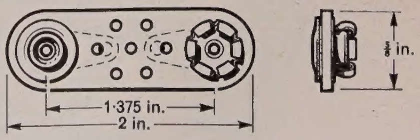


For use in pairs on batteries B101, B117, B131, B139, PP1, PP7, PP8 and PP9





For use on batteries PP1, PP8 and PP9



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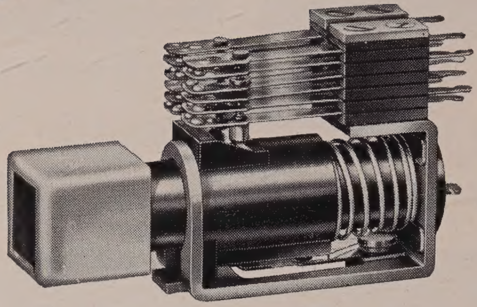

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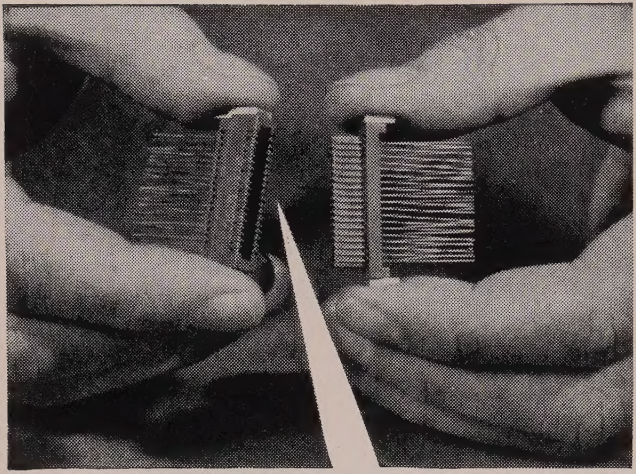

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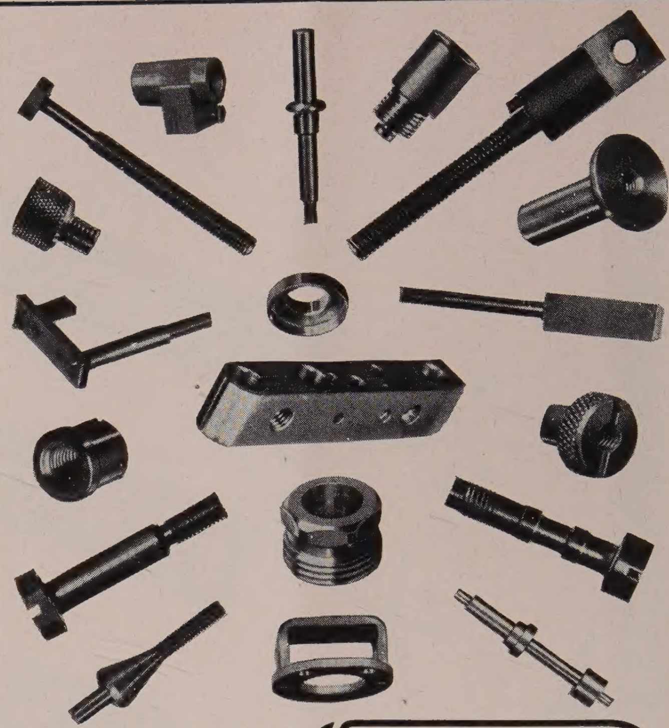

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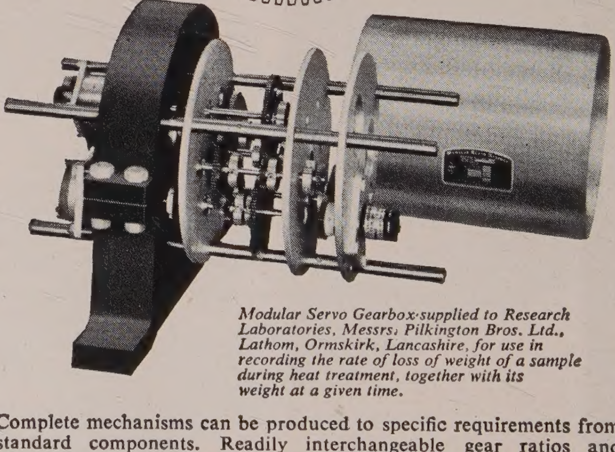

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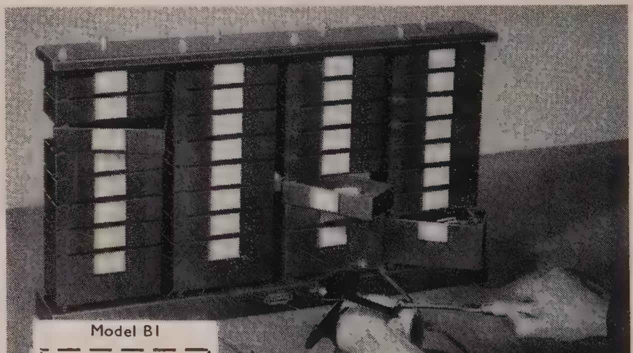
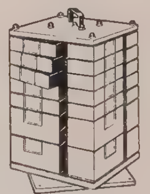


Model B1

Model C



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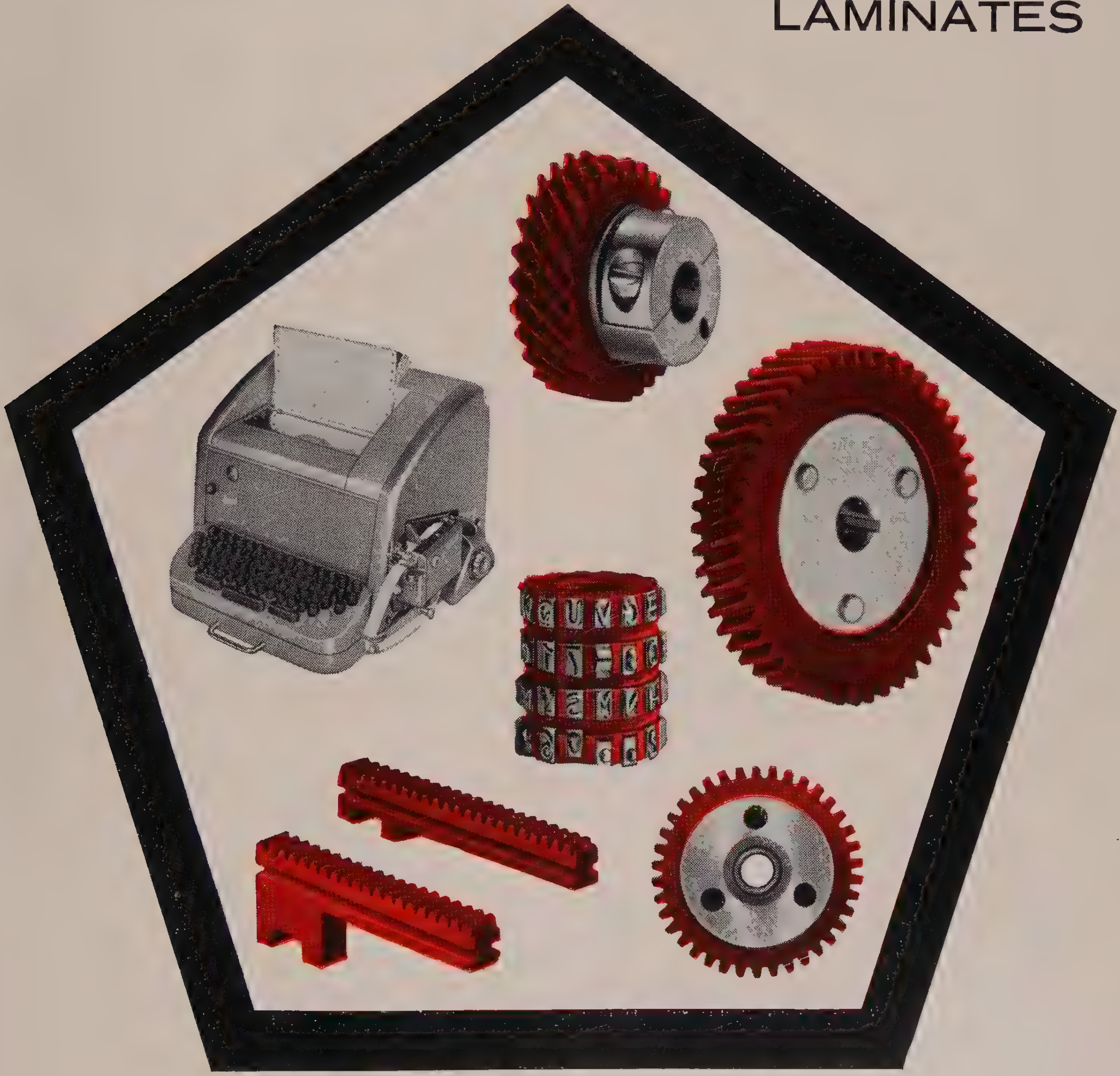

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Commentary

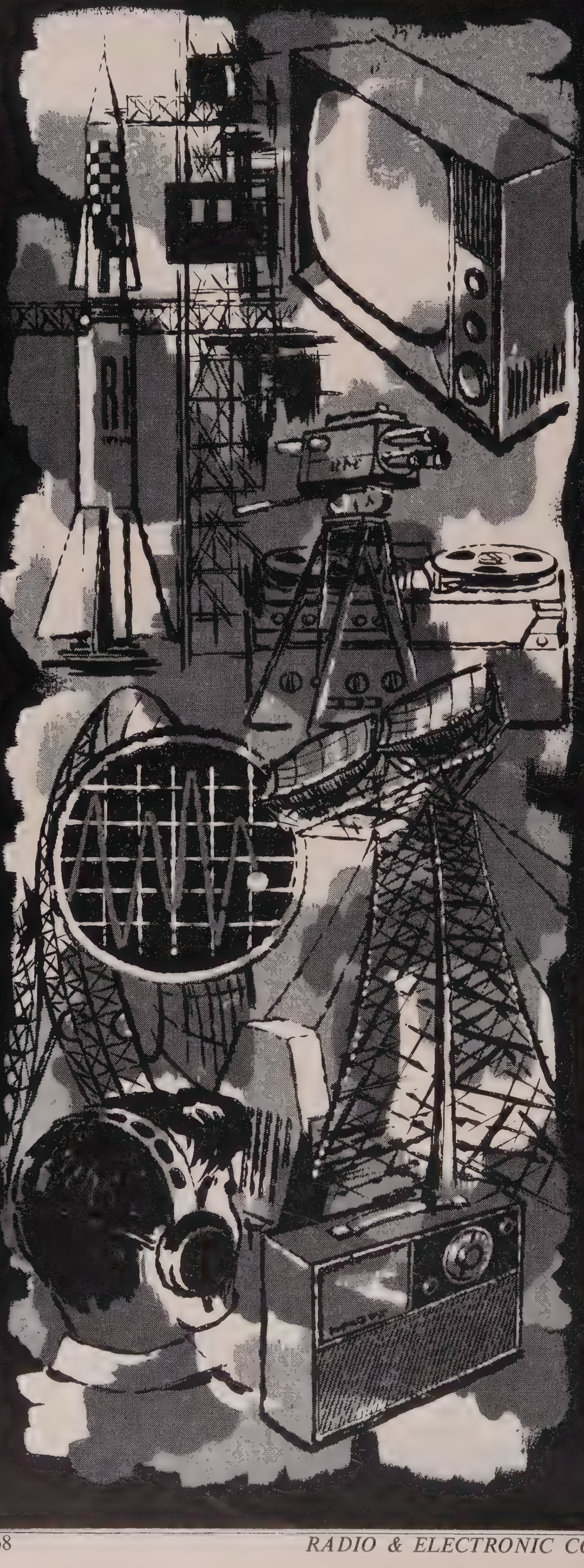
Cart Before the Horse

IT sometimes comes as something of a shock to realize just how fast techniques in the components field are developing. It is certainly a fact that many recently-developed devices, especially in the semiconductor field, will have no industrial or commercial applications for at least two years. Tunnel diodes, for instance, were hailed as a significant advance when they were first developed more than three years ago, but they have not, as yet, established themselves as a good commercial proposition simply because their present applications are extremely limited.

There is no doubt that industry requires a major incentive to keep its technological advances in line with those of other countries. The exploration of space provides the main incentive for both America and Russia, and we are fortunate that British component manufacturers provide a similar incentive to instrument and equipment designers by producing components which merit radical changes in the design and performance of scientific apparatus.

In the near future, we may look forward to the solid state circuit which then, we feel, becomes more of a component than a circuit. The possibilities of such a development are immense. Already an amplifier has been developed in England, incorporating about ten transistors, which is one-quarter of the size of the conventional amplifier for domestic sound reproduction. Apart from its size, the transistorized amplifier is capable of reproducing very good quality sound and its cost would be comparable to that of its more conventional relative. Solid state circuitry will enable even greater miniaturization in almost every field. Certain factors limit the lengths to which miniaturization can go, such as loudspeakers and cathode-ray tubes, but these problems are gradually being overcome.

It is important that research in the components field does not lag because of the apparent lack of applications for new developments. Generally, it is quicker and easier for designers to build around available and tested components than to wait for new ones to be developed for particular applications.



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TEXAS INSTRUMENTS LTD.

Opening of New Plant at Bedford

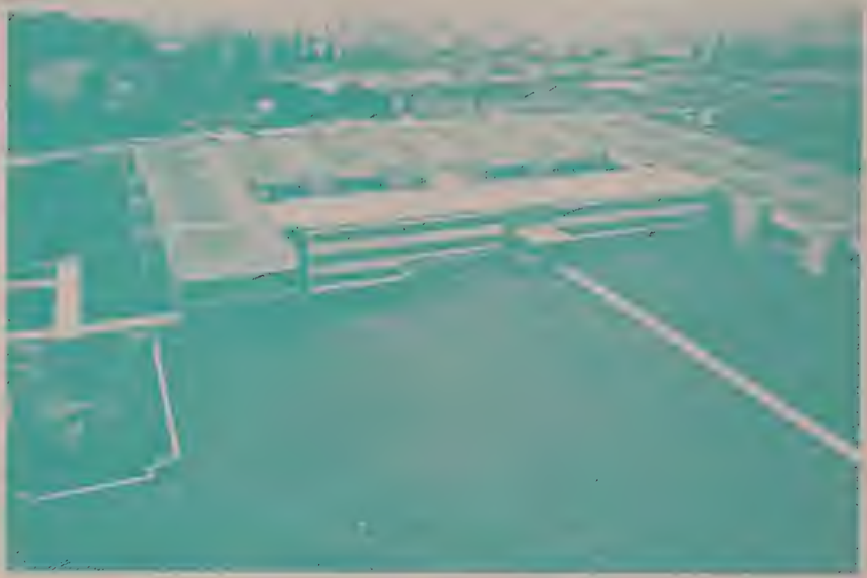


Fig. 1. The new Texas Instruments plant at Bedford showing the specially designed hyperbolic paraboloid roof.

THE NEW PLANT of Texas Instruments Ltd. at Bedford was opened officially on 27th June by Sir John Cockroft. Sir John recalled his visit to the Bell Telephone Laboratories when, about twelve years ago, he had watched Shockley's colleagues pulling single crystals of very pure germanium in very modern high vacuum equipment. The first transistors were in small-scale use, and he was able to take a few away in his pocket to stimulate the Harwell Electronics Division to make a start in studying transistor circuits. At this time there were plenty of doubters amongst users as to whether transistors would become important, but there were no doubts, Sir John said, in the mind of Mervyn Kelly and his Bell Laboratory staff. The work at Harwell had steadily developed, and transistorized instruments became commonplace.

Sir John felt that more important to science has been the transistorization of computers, which is making possible much higher speeds, greater reliability and less power consumption, so that major Universities such as Cambridge are looking forward to increasing their computing power by several orders of magnitude. This, in turn, will make possible many developments of major importance in the individual scientific departments, which would be impossible without such advanced aids. These very fast computers cost several million pounds with present technology. Sir John hoped, however, that with the rapid development of semiconductor technology now proceeding, costs could be so much reduced that they could be available to many Universities five to ten years from now.

Sir John stated that he had lately learnt about the development of semiconducting solid circuits which use germanium or silicon as a base material and which can be made to perform the function of a complete circuit incorporating the functions of resistors, capacitors, etc. A multivibrator containing the equivalent of six conventional components now measures only $\frac{1}{4} \times \frac{1}{8} \times 0{\cdot}03$ in.; a hundred-to-one reduction in size compared with printed circuits. Miniaturization of circuits was therefore carried one or two orders of magnitude further down the scale, so that in future 1,000 circuit elements might be stored in a cubic centimetre. This reduction of volume will be important technically in very high-speed computer operations, since in these one comes up against the limitations set by the velocity of radio waves.

Sir John pointed out that all the knowledge required to fabricate these new circuit elements was now available to Texas Instruments Ltd., and that the development and application of the new elements would proceed at Bedford.

The New Plant

The new plant is situated on a hilltop site to the north

Fig. 2. Sir John Cockroft.

of Bedford and is designed to blend with the landscape and the skyline. Based on methods originally used in the plant at Dallas, Texas for the Semiconductor Components Division of Texas Instruments Inc., the design was modified in the light of subsequent experience to meet local conditions. The most important of the characteristics of the new building was to be its flexibility in order to allow for the rapid progress and rapidly changing processes essential in the production of semiconductor devices.

Two of the most significant concepts in the design are the 10 ft. "pipe space" under the manufacturing floor, with access holes at 10 ft. centres into the manufacturing area above, and the roof formed of hyperbolic paraboloids in thin-shell concrete, rather like umbrellas turned inside out. Each four-sided unit covers a 50 ft. square area of uncluttered, uninterrupted floor space and there are 25 roof units in all covering as many bays. Sole roof support is provided by a hollow pillar at the centre of each bay with the pillar also acting as a rainwater drain.

The pipe space under the manufacturing floor contains a maze of pipes and conduits carrying the many supplies necessary for manufacturing. Included are various voltages of electrical power, gases such as town gas, hydrogen, nitrogen and argon, demineralized water, normal cold water and hot water, air, vacuum, waste, and process drainage by a special system of chemical effluent drains, all extending up into the manufacturing area in a regular pattern of outlets which can be tapped to serve any arrangement of equipment. This pipe space completely eliminates the clutter of cables and pipes placed on the floors or suspended from the ceiling in buildings of conventional design and permits easy access by maintenance staff.

Eventually the building will be approximately 430 ft. square. It will comprise a three-storey office block 270 ft. long by 50 ft. wide, surrounded on all sides by the manufacturing area in the shape of a hollow square. Two-storey links connect the centre of the office block to the manufacturing area, and access is also provided at both ends of the offices. The present stage of development includes the completion of the office block and two-thirds of the manufacturing area.

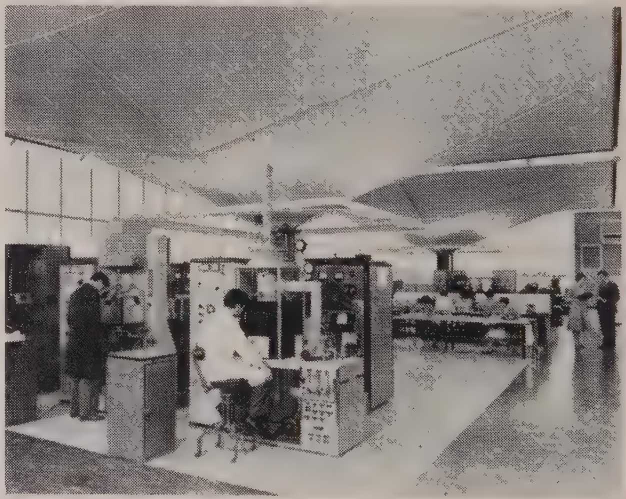
History of Texas Instruments Ltd.

When the United Kingdom began to look to the U.S.A., some seven years ago, for supplies of silicon transistors, Texas Instruments Incorporated played a prominent part in the export of these components which were already in large-scale production in Dallas. The Company's progressive policy of seeking, identifying and defining market requirements lead to the birth of the Texas Instruments International Semiconductor Operation towards the end of 1956 with the decision to set up Texas Instruments Ltd. in the British Isles to serve the need for a home-based supply of small, light, rugged, high-quality silicon components capable of operation over a wide range of temperatures.

The idea of adding to Bedford's light industry a rapidly growing component part of one of the world's leading corporations in the broadening field of semiconductor technology was immediately acceptable to the Local Authority. Consequently, Texas Instruments secured the necessary approval from the Borough Council at the beginning of January 1957 only a few days after it had been decided to base the new operation at Bedford. By 16th January, the Board of Trade in London had also given its approval, and the new plant was opened on 1st October, 1957.

Due to the increasing participation by Texas Instru-

Fig. 3. Machines for growing silicon crystals.



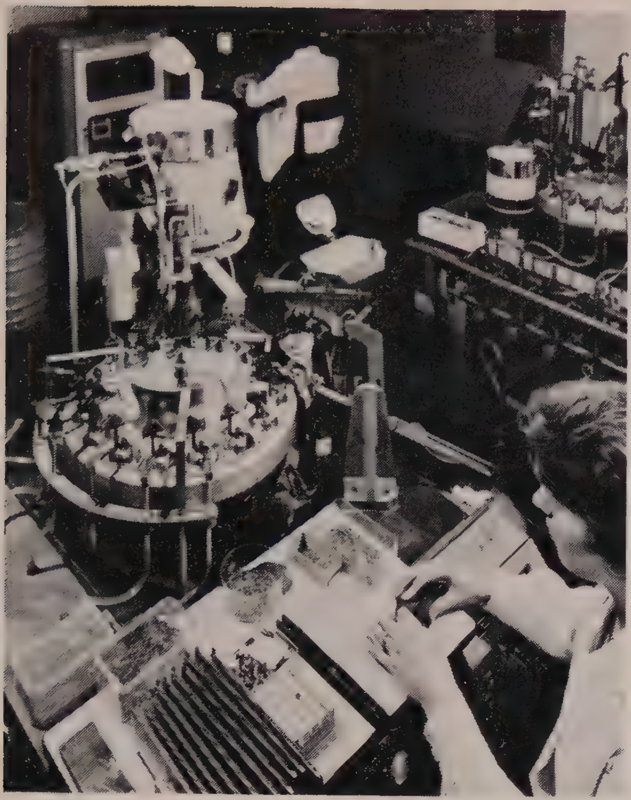


Fig. 4. Automatic sealing machine for Moly G miniature glass diodes.

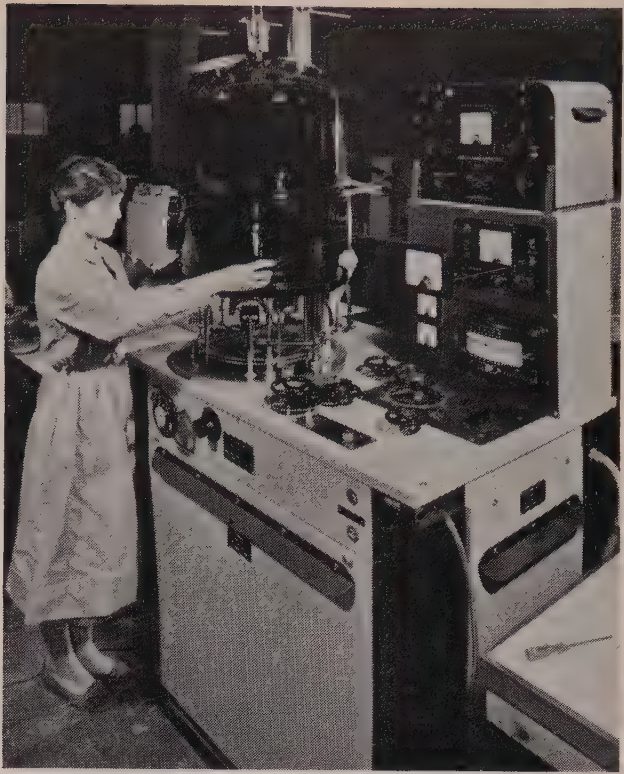


Fig. 6. Coating unit for germanium mesa transistors.

Fig. 5. Mr. A. Normand Provost.

ments Ltd. in the semiconductor market in this country, further facilities were soon needed and in October 1958 a second building came into operation bringing the total capacity to 20,000 square feet.

On 1st January, 1959, Mr. Cecil Dotson was appointed Chairman of the Board of Directors of Texas Instruments Ltd. The earlier growth pattern was accelerated during that year with the emphatic need to improve further production methods, reduce costs and build up greater quantities of production. By the end of 1959 total plant space was 32,000 square feet. Production consisted of silicon grown junction transistors, silicon diffused medium power and power transistors and the familiar moly-G, top hat and stud mounted rectifiers. In addition to these devices manufactured at Bedford, market coverage was widened by the opportunity of marketing semiconductor components of advanced design imported from Dallas.

1960 commenced with the proposed Manton Lane plant on the horizon and plans went ahead to re-shape the organization of Texas Instruments Ltd. in preparation for meeting the large volume requirements of the industrial market, once the new building became available. The immediate objective was, therefore, to broaden the range of existing devices, to extend production to germanium transistors, and to establish large volume low cost manufacturing techniques.

Continued on p. 588

MAINTAINING SPECIFIED STANDARDS FOR COMPONENTS

By S. F. Snowden

Applications Engineering Department

Honeywell Controls Ltd.

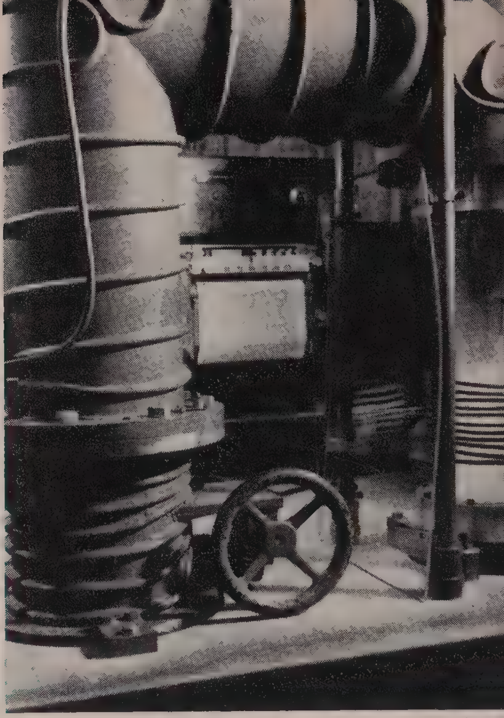


Fig. 1. The Honeywell strip chart recorder/controller in th ground maintains a temperature of 1420°C within ±0·25° crucible of silicon within the vessel on the right; a single c being pulled.

Electronic components have always tended to be more refined in design and in production than those associated with heavier industrial equipment, but developments in recent years have called for the maintenance of standards of precision and production control undreamed of a few years ago. In devising methods of achieving these high standards, the industry has acted as a forcing-ground for new techniques of measurement and control which have become widely applied in other fields. This article describes control equipment developed to solve many of the problems involved in achieving such standards.

Semiconductor production

THE STORY of semiconductor development during the last ten years provides a classical example of the way in which laboratory standards of quality control have been successfully applied on a mass-production scale. The problem of maintaining precise control of temperature during the pulling of semiconductor monocrystals was discussed recently in these pages,* with a brief description of a laboratory set-up concerned with the production of special crystals for research purposes. In this case an electronic recorder-controller maintained with great reliability the conditions which in the early stages of semiconductor work were established only by painstaking trial and error, and despite the limitations of human control.

The ability of this type of controller to bridge the gap between laboratory and production floor is illustrated by its use in the development department of the Southampton works of Mullard Ltd. This department is concerned with the development of new types of semiconductor materials, for which work a constant of crystals of differing specifications is required. The crystals are produced in the set-up shown in Fig. 1, which is in constant production, turning out two or three single crystals per day. The control requirements here are even more stringent than those imposed on mass-production lines, because of the flexibility required to deal with different materials. At the same time, the rate of output and the trouble-free operation required of the unit are more in line with production equipment than with research laboratory facilities.

Need for accurate control

The single crystal, in this case of silicon, is grown in a silica-lined carbon crucible, seen in the foreground of Fig. 2, which is heated at the base of the double-walled, water-cooled Pyrex glass cylinder at the right of Fig. 1. The silicon powder is melted by high-frequency induction coils, themselves of water-cooled copper tubing, round the cylinder. Depending on the material being grown, the atmosphere in the cylinder is either evacuated or filled with argon at atmospheric pressure, the vacuum pump being beneath the table at the left. The vacuum circuit is water-cooled by the pipes which can be seen brazed to the cylindrical metal vessels.

When the molten silicon has reached the required temperature, in this case about 1420°C, growing is initiated by a seed crystal shown in Fig. 2, which is lowered slowly into the melt by a rod passing down through the top of the vessel. The rod is rotated at a rate of several revolutions per minute, while being withdrawn vertically at a very low speed. The familiar single crystal is thus drawn gradually up out of the melt, and may be seen, about three-quarters complete, in Fig. 1.

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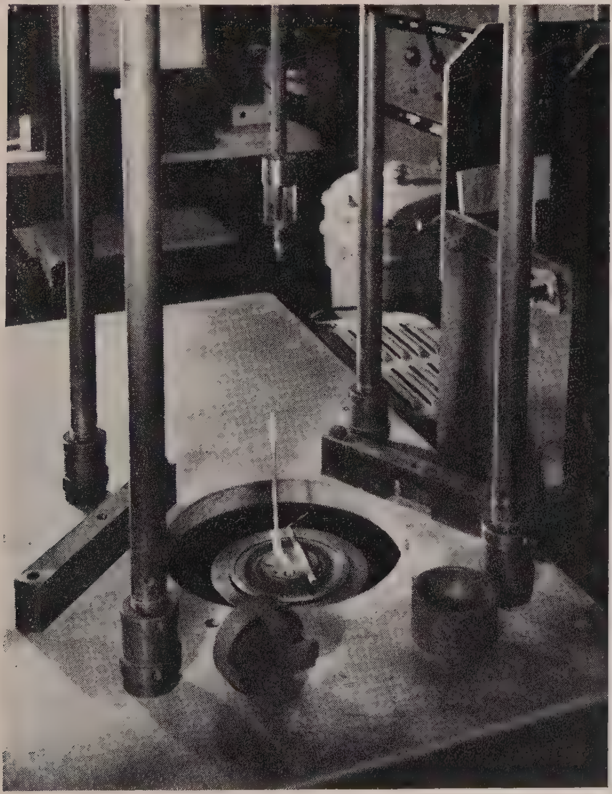
* Hopley, J. I.: *Temperature Control for Crystal Pulling*, **Radio and Electronic Components**, pp. 721-722 (Dec., 1960).

Three factors critically affect crystal quality. Variations in the rate of withdrawal or in the speed of rotation may cause discontinuities resulting in "twinning", or other faults in the crystal structure. The third factor, temperature, controls the thickness of the crystal at a given speed of rotation. An increase in the former, or a reduction in the latter, will cause a reduction in the diameter of the crystal. Apart from the danger of a sudden change in diameter affecting the structure of the crystal, constant thickness is necessary to ensure the economic use of the many pounds' worth of material in a single crystal. The crystal is later sliced longitudinally and transversely to produce a very large number of transistors of the same quality for test purposes, and any change in diameter results in considerable wastage.

Withdrawal and rotation rates are comparatively easy to control, but temperature is a different matter. The slightest variation must be detected immediately, and corrected before any damage is done. At the same time, experience has shown that planned changes in temperature must be made to compensate for changes in the geometry of the melt as the level in the crucible falls. Control is carried out by the recording instrument visible in the background of Fig. 1, and shown, opened, in Fig. 3. This instrument is typical of the range manufactured by Honeywell Controls Ltd., of Greenford, Middlesex, and used throughout industry where high standards of control, of almost any variable, are required. The sensing element is a platinum/platinum-rhodium thermocouple, encased in a tantalum sheath, which can be seen in Fig. 2. The thermocouple passes up through a hole in the cruciform support for the crucible, and just touches the base of the crucible itself. The tantalum sheath protects the platinum, which is embrittled by carbon at high temperatures.

Fig. 2. Melt temperature is measured by a platinum/platinum-rhodium thermocouple, in a protective tantalum sheath, which passes up through the carbon support (left foreground) to the base of the crucible (right), which is lined with silica. The seed crystal is above the thermocouple.



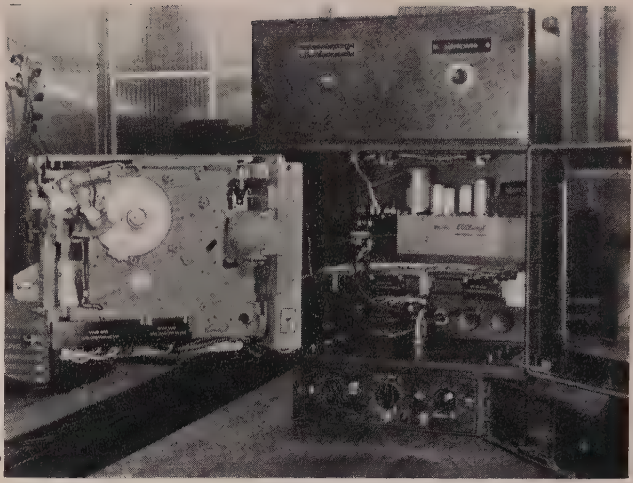


Fig. 3. The recorder controller opened to show the ElectroniK continuous balance unit in the rear of the case. The balancing potentiometer lies across the top of the open cover, with the balancing motor in the centre. Controls at the base adjust the proportional band and reset rate.

Continuous balance

The controller operates on the well-known ElectroniK "continuous balance" principle. The voltage output from the thermocouple is balanced against a standard voltage source. Any unbalance is converted to a proportional a.c. voltage, amplified, and used to drive a balancing motor which adjust a slidewire potentiometer in the required direction, and by the necessary amount, to restore balance in the system. At the same time, the motor drives the recording pen, which thus moves across the chart in proportion to the amount of deviation from the desired value. The balancing movement is also applied to operate the controlling means, in this case an Electr-O-Line circuit operating a control motor shown in Fig. 4, which adjusts a potentiometer in the output stage grid circuit of the heater unit. In the Electr-O-Line unit, a feedback circuit controlled by a slidewire on the control motor ensures a continuous balance state in the control circuit.

Proportional control

Although a simple "on-off" type of control system might suffice to maintain the temperature within fairly close limits, it has been found that pulsations of power to the induction coils tend to produce turbulence in the melt and to decrease the life of the heating equipment.

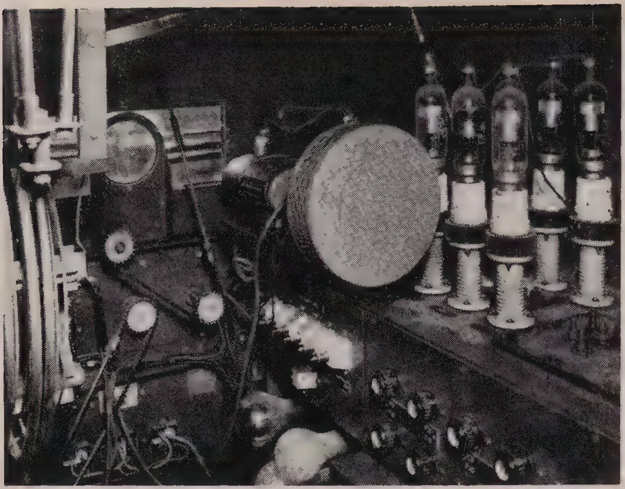


Fig. 4. The controller operates the motor-driven potentiometer in the centre, which adjusts the grid circuit of the output stage of the h.f. heater to maintain the required temperatures in the crucible.

For this reason proportional control, affected by the Electr-O-Line system, ensures that the change in energy applied is proportional to the deviation from the desired temperature. The amount of control movement for a given deviation is preset, according to the characteristics of the whole system, to eliminate cycling. This factor is adjusted by a potentiometer in the controller circuit, controlled by the "Proportional Band" knob at the right of the base of the controller in Fig. 3. This, in effect, adjusts the width of that portion of the full range of the controller over which the control action is proportional to deviation. The narrower this band is, naturally, the greater the control action for a given deviation. In this case, the proportional band is set at about 10% of the full scale of the controller, which is 50°C. This means that the full range of control movement is available over a total range of 5°C about the desired value of 1420°C. The actual position of the 50°C band within the total temperature range is selected by adjustment of a control at the top right of the instrument.

Integral action

Since proportional control provides for only one position of the control element for a given deviation from the desired value, it cannot keep pace with changes in the process load, as for instance when the level of molten silicon falls. If left uncorrected, this would result in a continuous deviation from the required temperature. This contingency is catered for by an additional mode of control, called integral action or "reset". This has the effect of moving the proportional band across the scale whenever the temperature varies, the amount of shift being proportional to the duration and magnitude of the deviation. Thus, a sustained tendency for the temperatures to increase or decrease is met by an increasing amount of shift of the proportional band, and a correspondingly greater or lesser amount of control action to counteract the offset.

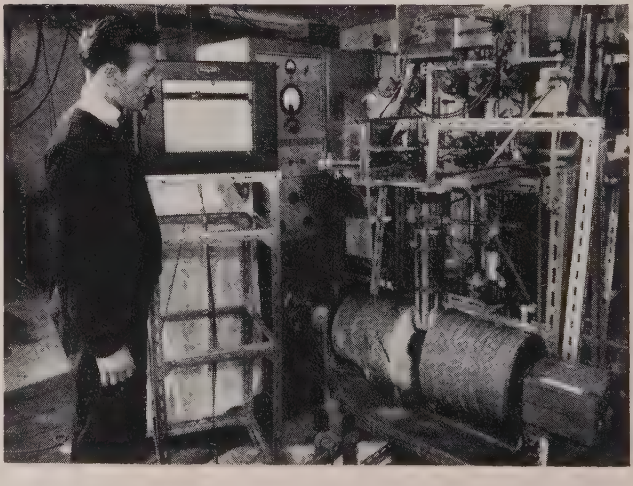
The actual rate of reset, that is to say the rate at which the band is moved, is preset, and can itself be adjusted, by a further potentiometer control at the bottom left of the controller. This **proportional-plus-reset** system of control permits accurate and sensitive control of temperature, without excessive lag or cycling in conditions such as those involved in crystal pulling, where the capacity of the system is small, rapid changes can take place, and the process load varies. It also adjusts very rapidly to the deliberate changes in the set temperature, introduced manually at various stages in the process, which experience has shown to be necessary.

The inherent accuracy of the controller is well illustrated by the fact that, at the high temperature involved, the spot reading is held at all times within 0·25°C. It is control as close as this which had been one of the main factors making possible the almost routine production of transistors and other semiconductor devices today.

Wide application

The principle of continuous balance control and the refinements incorporated in the instrument described above have been dealt with in some detail, because they apply equally to the wide range of Honeywell instruments measuring, recording and controlling every conceivable variable met with in electronic research and production. An example of the former, which illustrates the versatility of these units, is shown in Fig. 5* taken at the Radar Research Establishment of the Ministry of Aviation, at Great Malvern. The apparatus is used in basic research into the Hall effect, the transverse potential produced across a conductor in a magnetic field when a current is passed along it. The Hall effect depends greatly on the chemical composition of the conductor, and has been found a very useful measure of the impurities present in semiconductor materials. It is also

Fig. 5. Hall effect research at the Royal Radar Establishment. A semiconductor specimen between the magnet poles is maintained at liquid helium temperatures. The recorder on the left measures Hall effect voltages with high accuracy and much greater speed than by any other means.



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finding application as a means of detecting and measuring very weak magnetic fields, particularly in geological survey work.

The production of useful data on the Hall effect is not an easy task. The effect is most marked at very low temperatures, which restricts the time available in which to take as many readings as possible under different conditions of applied current, magnetic field and over a small range of temperatures. The effect of slight temperature changes in particular is very strong, so that the measuring instrument must have a wide input range, not easy to combine with ultra-high sensitivity.

In the set-up illustrated, the specimen is mounted within a double Dewar vessel, the outer cavity being filled with liquid nitrogen, the inner with liquid helium. The whole assembly is placed between the poles of a powerful electromagnet, producing fields up to about 7,000 gauss. The connections across which the Hall potential is measured are taken to the Honeywell recorder on the left, which has been specially modified by the makers for this work. Its input impedance range, extending up to 50 kΩ, is said to be about 50 times wider than that available from previous instruments of similar type. This feature is coupled with an automatic range-changing device, controlling two recording pens. The first of these indicates 5 mV steps across the total acceptable range of −15 mV to +15 mV, the second pen using the full scale to interpolate between the steps. Thus the full scale accuracy is applied to each 5 mV step.

Spot readings are taken every five seconds, which represents a great advance over the speed of manual plotting, and permits accurate and rapid plots to be made covering a wide range of applied current, temperature and field strength, in a fraction of the time formerly required. Since the work is carried on more or less continuously under different conditions, the saving is a very real one.

Co-ordinate plotting

The above example illustrates that the recording of accurate data may be as important in the field of quality control as the actual control of variables. The techniques are already being applied as a means of detecting impurities in semiconductor materials. The instrument described is representative of many types of indicators, strip chart and circular scale recorders used to keep a continuous check on temperatures, pressures and other variables in the production of high-quality components.

The latest type of instrument to become available represents a further important step forward in the presentation of information at a rate far higher, and with an accuracy much greater, than could be achieved by manual methods. In the ElectroniK function plotter, shown in Fig. 6, the continuous balance principle is applied not only to the recording pen, but also to the strip chart drive mechanism, which can move in either direction. Electrical inputs, proportional to any two variables, can be fed to the two balancing circuits, so that a continuous plot of the type $y=fx$ can be made. Alternatively, the chart can be driven by a Selsyn drive, where one co-ordinate represents a mechanical motion.

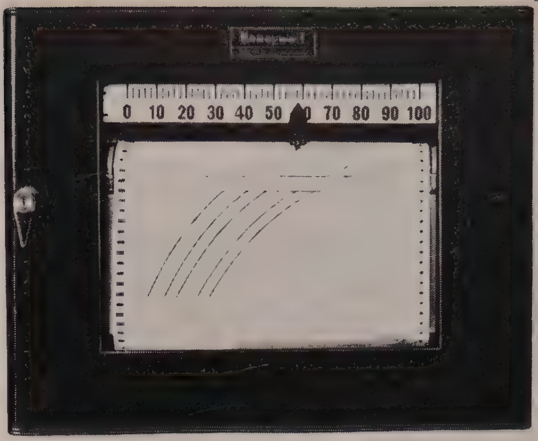


Fig. 6. Separate ElectroniK measuring circuits drive recording pen and chart on this function plotter. Curves representing valve characteristics, hysteresis behaviour, and other relationships involving two variables are presented clearly and accurately.

Although the instrument has application to many industries, because with suitable sensing elements it can plot any conceivable variables, it is expected to be of special importance to the electronic industry, providing as it does a convenient and accurate means of plotting valve characteristics such as anode current *versus* grid voltage, hysteresis loops, and response curves of many kinds. As a production tool, it can play as important a part as the family of controllers and recorders described above, ensuring that every component measures up to the performance standards laid down in the laboratory.

* * *

Courses for Students

THE South East London Technical College is to hold a six-months' full-time course for students wishing to sit for the Institution of Electrical Engineers—Part III Examinations. The course will begin on 16th October, 1961 and will finish in May, 1962.

Prospective students should have been awarded the Higher National Certificate in Electrical Engineering with endorsements in "mechanics" and "physics" (heat, light and sound), and have qualified in English or have passed Parts I and II of the Institution's examinations.

The London fee for the complete course is £17.

A further course is to be held on "Electric Circuit and Field Theory". This will consist of approximately twenty-five lectures and students intending to sit for the Part III examination of the Institution of Electrical Engineers should find the course of particular interest.

The fee for the course is £1 10*s*.

Applications should be made to the Head of the Electrical Engineering and Applied Physics Department, South East London Technical College, Lewisham Way, London, S.E.4 as soon as possible.

High-Stability Ferrite Pot Cores

This paper, which was read at the Brit. I.R.E. symposium on new components held in October, 1960, describes a range of ferrite adjustable pot-core assemblies suitable for use in laboratories and for the bulk production of stable inductor units. In addition, general results on accelerated stability measurements are given. The papers read at the symposium are to be printed in full in the Journal of the British Institution of Radio Engineers. Permission from the Institution to publish this paper, published in the May issue of the Journal, is gratefully acknowledged.

By W. A. Everden, Mullard Ltd.

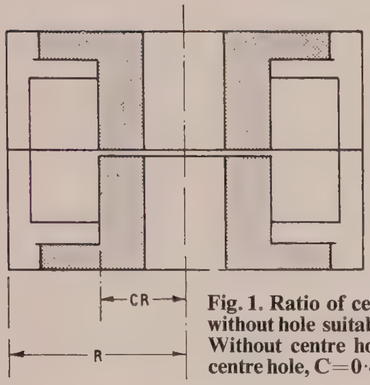


Fig. 1. Ratio of centre core diameter with and without hole suitable for adjusting mechanism. Without centre hole, C=0·386; with typical centre hole, C=0·445.

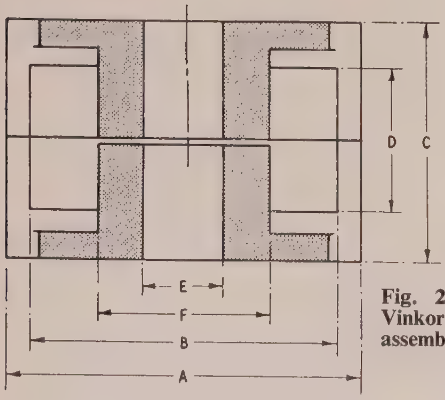


Fig. 2. Dimensions for Vinkor range of pot-core assemblies.

Nominal size (mm.)	A (mm.)	B (mm.)	C (mm.)	D (mm.)	E (mm.)	F (mm.)
14/9	14·0	11·6	9·6	3·6	3·6	6·1
16/10	16·0	13·2	10·2	6·6	3·6	6·8
18/11	18·0	15·1	11·2	7·4	4·6	8·0
21/13	21·5	18·0	13·6	8·8	4·6	9·7
25/16	25·4	21·4	16·0	10·4	5·4	11·4
30/18	29·5	24·3	18·8	12·2	5·4	13·8
35/23	35·5	29·2	22·8	14·8	5·4	16·3
45/29	45·0	37·2	29·2	19·0	5·4	20·3

List of Symbols

μ_e	Effective permeability of a gapped core.
μ_i	Initial permeability.
α	Number of turns for one millihenry.
$\tan \delta_{r+e}$	Residual plus eddy current dissipation factor.
$(\tan \delta)/\mu_i$	Total loss factor.
R_{cu}	D.c. resistance of winding.
L	Inductance in henries unless otherwise stated.
Q	Quality factor.
H	Magnetizing force in oersteds.
A_e	Effective core area $= \dfrac{\Sigma l/A}{\Sigma l/A^2}$ cm^2
l_e	Effective core magnetic path length $= \dfrac{(\Sigma l/A)^2}{(\Sigma l/A^2)}$ cm.
V_e	Effective core volume $= \dfrac{(\Sigma l/A)^3}{(\Sigma l/A^2)^2}$ cm^3
A	Cross-sectional area of magnetic core in cm^2.
l	Length of flux path in cm.
F_h	Hysteresis factor.

1. Introduction

When beginning the initial design work on the pot-core assemblies described in this paper, it was appreciated that many types of pot-core assembly were readily available. Few of these, however, were considered to form a complete range designed to give optimum performance when used in filter applications. In addition, existing components did not exploit fully the latest techniques and knowledge within the ferrite industry which were required for modern methods of coil production.

TABLE 1. GENERAL MATERIAL PROPERTIES OF THE TWO GRADES OF MANGANESE ZINC FERRITE USED FOR THE VINKOR RANGE OF POT CORES

Property	Conditions of test	Limit values	
		Frequency range (<100 kc/s)	Frequency range (100 kc/s—2 Mc/s)
Initial permeability μ_i	$\leqslant 0{\cdot}5$ G	$\geqslant 1150$	$\geqslant 600$
Temperature factor ($d\mu_i/\mu_i^2 dT$)	$\leqslant 0{\cdot}5$ G	$\leqslant 2\times10^{-6}$ deg.$^{-1}$ C	$\leqslant 2{\cdot}5\times10^{-6}$ deg.$^{-1}$ C
Curie point	$\leqslant 0{\cdot}5$ G	$\geqslant 150$°C	$\geqslant 150$°C
Hysteresis change 4 kc/s 100 kc/s	$\leqslant 20$ G	$\leqslant 0{\cdot}97\times10^{-6}$	$\leqslant 1{\cdot}16\times10^{-6}$
Magnetic induction	$H=10$ oersted	$\geqslant 3400$ G	—
D.C. resistivity	—	$\geqslant 20\,\Omega$ cm	$\geqslant 150\,\Omega$ cm
Loss factor tan δ/μ_i			
4 kc/s	$\leqslant 0{\cdot}5$ G	$\leqslant 2{\cdot}5\times10^{-6}$	
30 kc/s		$\leqslant 6{\cdot}0\times10^{-6}$	
100 kc/s			$\leqslant 10\times10^{-6}$
500 kc/s			$\leqslant 14\times10^{-6}$
1000 kc/s			$\leqslant 32\times10^{-6}$
Disaccommodation	—	$\leqslant 2{\cdot}5\%$	$\leqslant 2{\cdot}5\%$

(All values refer to measurements on standard toroids at 20°C ±5 deg. C)

TYPICAL VALUES OF MECHANICAL PROPERTIES

Specific gravity,	4·8
Tensile strength,	2,600 lb/in^2
Crushing strength,	10,000 lb/in^2
Youngs modulus,	24×10^6 lb/in^2
Coefficient of linear expansion,	10×10^{-6} deg.$^{-1}$ C
Thermal conductivity,	0·008 cal/s/cm deg.$^{-1}$ C
Specific heat,	0·17 cal/gm deg.$^{-1}$ C

2. Optimum Pot-core Shape

Neither the scope nor length of the paper allows a complete discussion of the many parameters which influence the introduction of such a range of components. However, as the majority of pot cores used are for applications below 100 kc/s, it was decided to base the calculations leading to the establishment of optimum core proportions on the following:

(*a*) The minimum ratio of d.c. resistance R_{cu} to inductance L for a given effective permeability, rationalized to be independent of volume.

(*b*) The maximum ratio of hysteresis volume to overall volume consistent with (*a*).

These assumptions are justified if it is remembered that for low-level applications the hysteresis loss is small and the residual core loss at the lower frequencies is also small, compared with that due to d.c. resistance R_{cu}. At such frequencies R_{cu} is usually equal to or greater than 50% of the total coil loss.

To maintain the requirements given under (*a*), the ideal core proportions do not include a hole in the centre core suitable for an adjusting mechanism although from calculations made this diameter is only increased slightly by a hole of typical size. The respective proportions are shown in Fig. 1.

While the requirements under (*b*) indicate that hysteresis loss is of secondary importance, it is probable that the larger cores will be used under conditions of increased level, making it desirable to increase the hysteresis volume. A substantial increase can be achieved at little expense to the low level performance by increasing the centre core diameter from optimum until R_{cu}/L has increased by approximately 1%.

Using the above ideas to obtain optimum performance, proportions can be calculated which are general, and any number of sizes within a range can be assumed. If the outside diameter is treated as a basic parameter the theoretical optimum height and internal configuration may be calculated. Dimensions for the Mullard Vinkor range of pot-core assemblies are shown in Fig. 2.

3. Effective Permeability

The permeability of an assembly contributes much to its final performance, and it is essential that the value be chosen with a complete knowledge of its effect on other parameters. At low frequencies there are advantages in making these values as high as compatible with any temperature coefficient or hysteresis requirements in order to obtain the lowest ratio of resistance R_{cu} to inductance L.

From the general expression for temperature coefficient of inductance $\frac{\mu_e d\mu_i}{\mu_i^2 dT}$ per deg. C it can be seen that the ultimate value is proportional to μ_e since the term $\frac{d\mu_i}{\mu_i^2 dT}$ is independent of core shape and effective permeability μ_e, and hence is a constant for any given material.

As polystyrene capacitors which have a temperature coefficient of approximately −60 to −200 parts in 10^6 per deg. C, are normally associated with ferrites in tuned circuits, it is desirable that a range of effective permeabilities be chosen so that the composite temperature coefficient approaches zero.

Using ferrites from the manganese zinc group, examples of which are shown in Table 1, this requirement is not always compatible with keeping the core loss to a minimum. However, a logarithmic series enables the coil designer to obtain either high Q or a lower value of temperature coefficient dependent upon his application.

3.1 Choice of effective permeability. The series chosen give primary standards of 160, 100, 63, 40 and 25 in which the increments are sufficiently small to provide a range of temperature coefficients which cannot economically be improved by intermediate values of permeability.

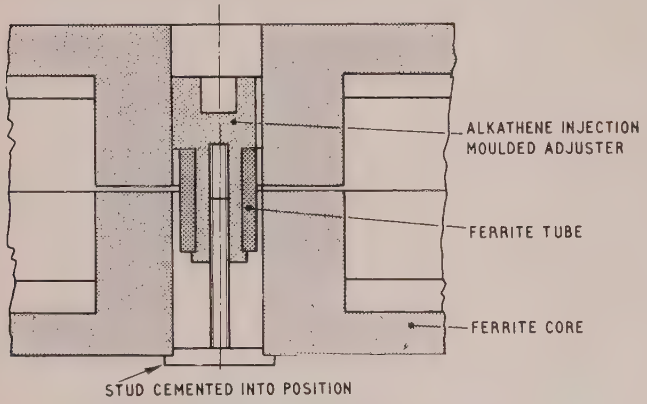

ALKATHENE INJECTION MOULDED ADJUSTER
FERRITE TUBE
FERRITE CORE
STUD CEMENTED INTO POSITION

Fig. 3. Sectional view of adjusting mechanism.

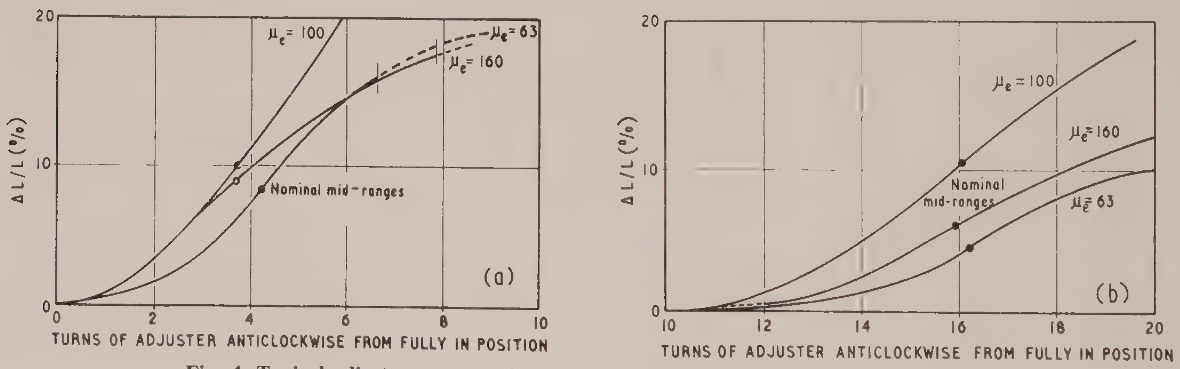


Fig. 4. Typical adjustment curves for (*a*) 18 mm and (*b*) 35 mm Vinkor pot-cores.

Actual values of effective permeability are maintained within close limits by mechanically introducing a small air gap into the cores and controlling the resultant value of turns/mH—α. Hence the designer may calculate the number of turns required for a given inductance, and then wind to this number of turns with the knowledge that the inductance will be within the stated accuracy, in most cases better than ±3%.

4. Adjusting Mechanism

A review of the various forms of adjusting mechanisms available will indicate that a great deal of thought has been given to this subject. (1, 2, 3)

However, most of the forms in common use do not constitute the ideal mechanism and usually suffer from one or more of the following imperfections:

(i) Non-linearity of adjustment;
(ii) Coarse adjustment;
(iii) Non-cyclic instability;
(iv) Local high induction, resulting in increased losses;
(v) Difficulties of manufacture.

Most of these difficulties are overcome by using a method of shunting the air gap, the most satisfactory results being obtained with a ferromagnetic slug moving axially and partially filling the hole in the centre core.

Fig. 3 shows the general form chosen. The central stud accurately locates the mechanism, whilst the five ribs around the periphery eliminate possible wobble and the resultant non-linearity of adjustment. The fine thread form allows a setting accuracy of better than 0·02% to be obtained, whilst the complete adjusting mechanism is substantially contained within the external dimensions of the cup cores and is completely independent of any additional clamping arrangements.

4.1 Range of adjustment. The stability of a complete inductor may be influenced by the amount of adjustment which should therefore be kept to a minimum consistent with the overall requirements of filter construction. A range of approximately 14% irrespective of effective permeability is considered adequate, made up as follows: ±3% or 6% variation for the cancellation of spread in effective permeability of cores, ±2% or 4% for capacitor tolerances, and approximately ±2% or 4% variation for final trimming of the complete network. Two sets of typical adjusting curves are shown in Fig. 4.

5. Housings

An exploded view of a typical housing suitable for

TABLE (2*a*). ELECTRICAL AND MAGNETIC DATA FOR THE VINKOR RANGE OF POT CORES SUITABLE FOR USE UP TO FREQUENCIES OF 200 kc/s

Nominal diameter of core assembly (mm.)	μ_e	α	Approximate frequency range (kc/s)	Typical values of $\tan\delta_{r+e}$		Hysteresis factor measured at 4 kc/s F_H (maximum)	Temperature Coefficient of inductance over 20–50°C (p.p.m. deg. $^{-1}$C)	μ_e Without adjuster	$\sum 1/A$ (cm^{-1})	$\sum 1/A^2$ (cm^{-3})	V_{eff} (cm^3)	L_{eff} (cm)	A_{eff} (cm^2)
				30 kc/s	100 kc/s								
18	160 100 63	52·5 66·4 83·6	Up to 100 Up to 100 Up to 200	$0{\cdot}576\times10^{-3}$ $0{\cdot}360\times10^{-3}$ $0{\cdot}226\times10^{-3}$	$1{\cdot}104\times10^{-3}$ $0{\cdot}690\times10^{-3}$ $0{\cdot}435\times10^{-3}$	35·8 17·7 8·84	0 to 320 0 to 200 0 to 126	146·5±3% 90·0±3% 58·0±2%	5·6	12·6	1·1	2·48	0·443
21	160 100 63	46·1 58·3 73·4	Up to 70 Up to 70 Up to 200	$0{\cdot}590\times10^{-3}$ $0{\cdot}370\times10^{-3}$ $0{\cdot}233\times10^{-3}$	$1{\cdot}120\times10^{-3}$ $0{\cdot}700\times10^{-3}$ $0{\cdot}440\times10^{-3}$	25·1 12·4 6·2	0 to 320 0 to 200 0 to 126	149·5±3% 89·4±3% 59·0±2%	4·25	5·87	2·22	3·07	0·724
25	160 100 63	42·5 53·8 67·8	Up to 40 Up to 70 Up to 200	$0{\cdot}600\times10^{-3}$ $0{\cdot}375\times10^{-3}$ $0{\cdot}236\times10^{-3}$	$1{\cdot}230\times10^{-3}$ $0{\cdot}770\times10^{-3}$ $0{\cdot}485\times10^{-3}$	19·6 9·7 4·85	0 to 320 0 to 200 0 to 126	146·5±3% 90·3±3% 59·0±2%	3·64	3·64	3·64	3·64	1·00
30	160 100 63	37·5 47·5 59·8	Up to 30 Up to 70 Up to 200	$0{\cdot}800\times10^{-3}$ $0{\cdot}500\times10^{-3}$ $0{\cdot}315\times10^{-3}$	$1{\cdot}760\times10^{-3}$ $1{\cdot}100\times10^{-3}$ $0{\cdot}693\times10^{-3}$	14·75 7·3 3·65	0 to 320 0 to 200 0 to 126	148·3±3% 90·0±3% 59·5±2%	2·82	1·85	6·57	4·31	1·53
35	160 100 63	34·3 43·4 54·7	Up to 20 Up to 50 Up to 200	$0{\cdot}880\times10^{-3}$ $0{\cdot}550\times10^{-3}$ $0{\cdot}346\times10^{-3}$	$2{\cdot}048\times10^{-3}$ $1{\cdot}280\times10^{-3}$ $0{\cdot}085\times10^{-3}$	10·92 5·4 2·7	0 to 320 0 to 200 0 to 126	150·4±3% 89·7±3% 60·1±2%	2·35	1·06	11·7	5·25	2·23

TABLE 2(*b*). ELECTRICAL AND MAGNETIC DATA FOR THE VINKOR RANGE OF POT CORES SUITABLE FOR USE OVER THE FREQUENCY RANGE 100 kc/s—3 Mc/s

Nominal diameter of core assembly (mm.)	μ_e	α	Approximate frequency range (kc/s)	Limit values of $\tan\delta_{r+e}$		Hysteresis factor measured at 100 kc/s F_H (maximum)	Temperature Coefficient of inductance over 20–50°C (p.p.m. deg. $^{-1}$C)	μ_e Without adjuster	$\sum 1/A$ (cm^{-1})	$\sum 1/A^2$ (cm^{-3})	V_{eff} (cm^3)	L_{eff} (cm)	A_{eff} (cm^2)
				100 kc/s	1000 kc/s								
18	63 40 25	83·6 105 142	Up to 700 Up to 2000 Up to 3000	$0{\cdot}55\times10^{-3}$ $0{\cdot}35\times10^{-3}$ $0{\cdot}23\times10^{-3}$	$1{\cdot}75\times10^{-3}$ $1{\cdot}1\times10^{-3}$ $0{\cdot}71\times10^{-3}$	8·9 4·5 2·3	0 to 158 0 to 100 0 to 62·5	58 ±2% 35·9±2% 22·1±3%	5·6	12·6	1·1	2·48	0·443
21	63 40 25	73·4 92·0 123·0	Up to 2000 Up to 2000 Up to 3000	$0{\cdot}55\times10^{-3}$ $0{\cdot}35\times10^{-3}$ $0{\cdot}22\times10^{-3}$	$1{\cdot}75\times10^{-3}$ $1{\cdot}1\times10^{-3}$ $0{\cdot}71\times10^{-3}$	6·2 3·2 1·6	0 to 158 0 to 100 0 to 62·5	59 ±2% 35·9±2% 22·6±3%	4·25	5·87	2·22	3·07	0·724
25	63 40 25	67·8 85·1 115·0	Up to 700 Up to 1200 Up to 3000	$0{\cdot}55\times10^{-3}$ $0{\cdot}35\times10^{-3}$ $0{\cdot}23\times10^{-3}$	$1{\cdot}75\times10^{-3}$ $1{\cdot}1\times10^{-3}$ $0{\cdot}71\times10^{-3}$	4·9 2·5 1·3	0 to 158 0 to 100 0 to 62·5	59 ±2% 35·7±2% 22·1±3%	3·64	3·64	3·64	3·64	1·00

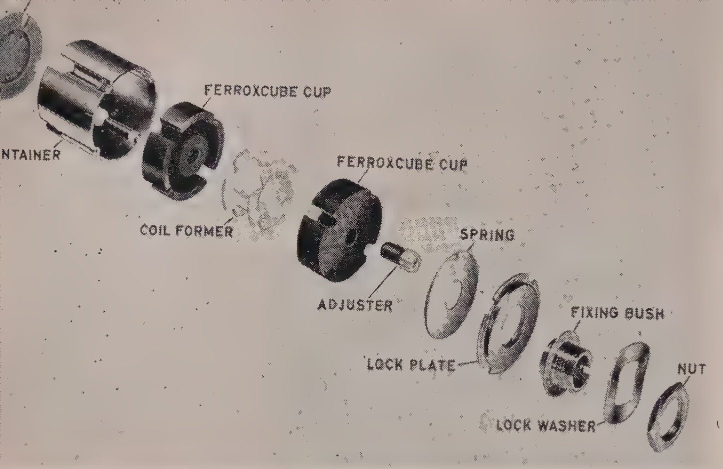


Fig. 5. Exploded view of Vinkor pot-core assembly.

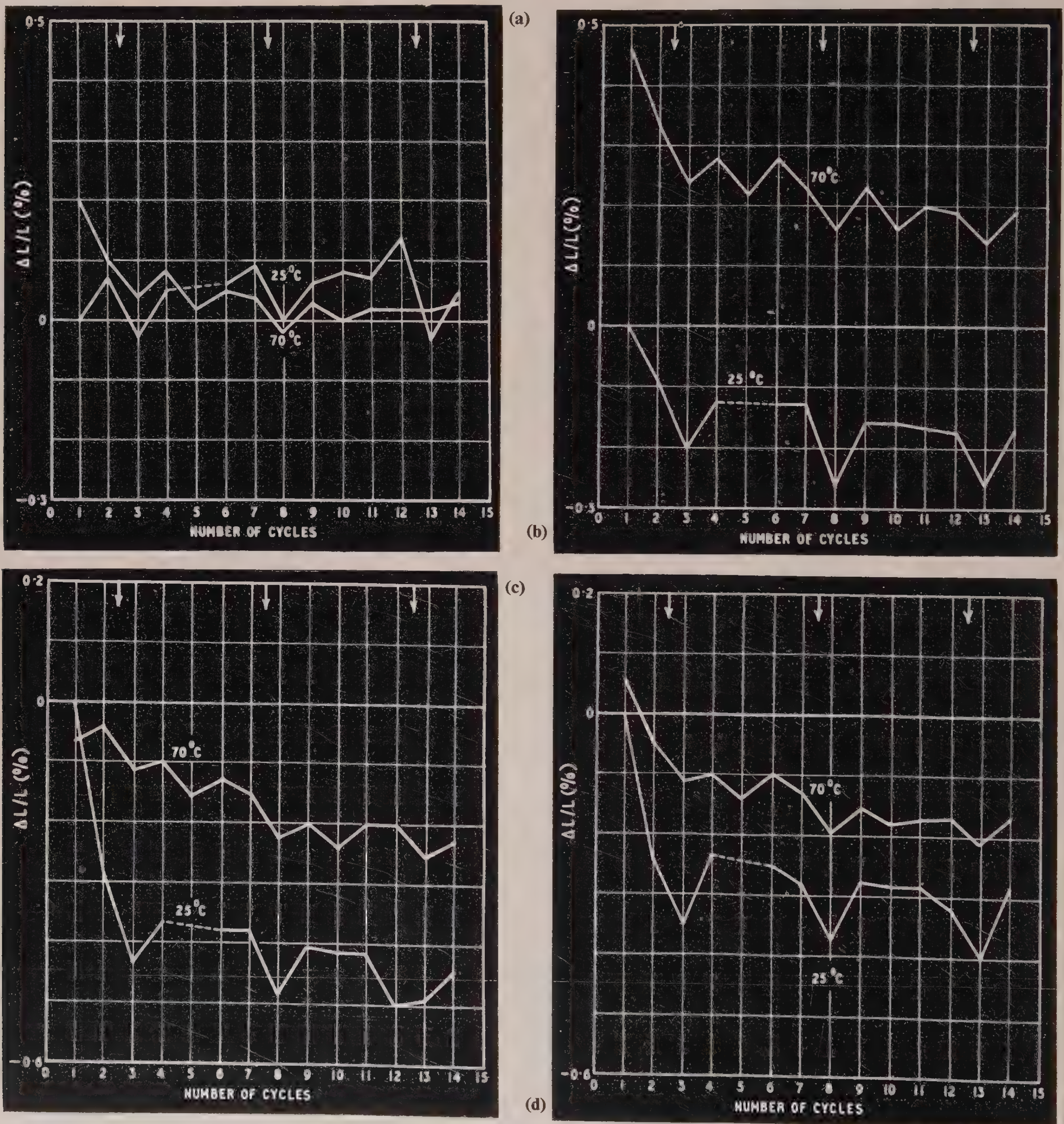


Fig. 6. Effect of temperature on the stability of 25 mm Vinkor pot-cores; effective permeability, 100. Arrows indicate weekend running. (*a*), Coil former DT2083, impregnation dry; (*b*), coil former DT 2010, impregnation dry; (*c*), coil former DT 2083, impregnation Okerin 4148; (*d*), coil former DT 2010, impregnation Okerin 561.

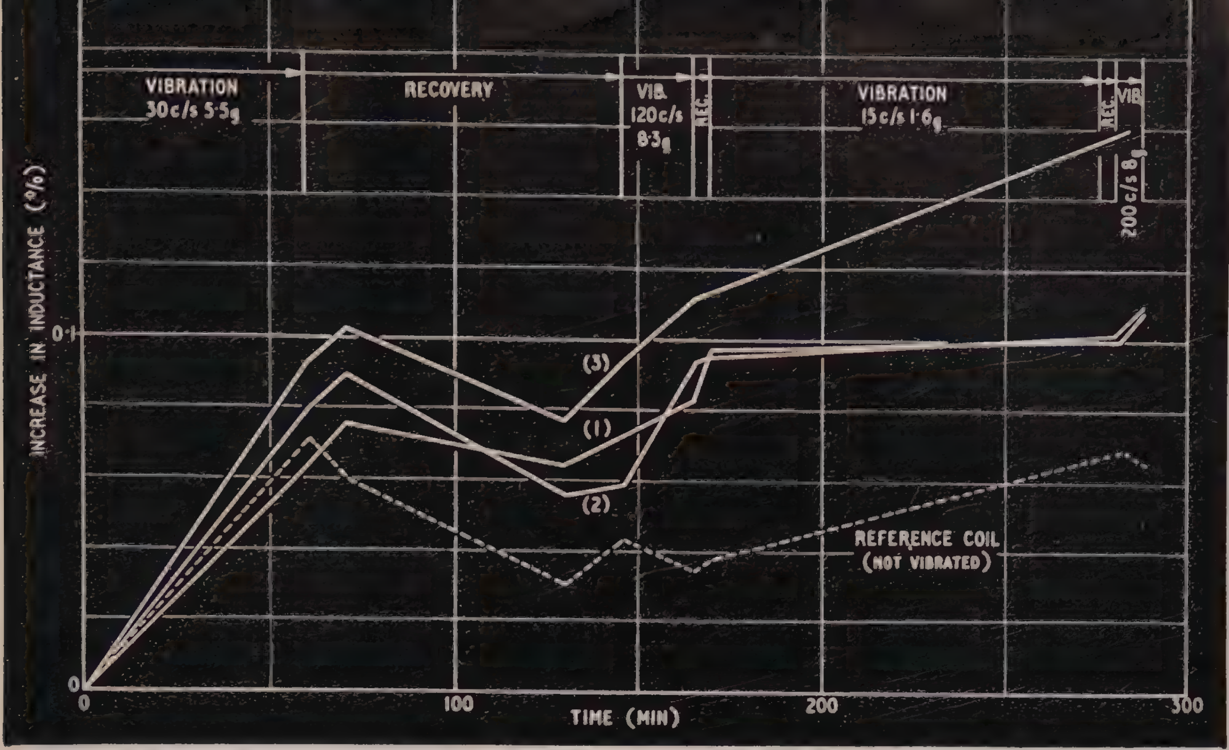


Fig. 7. Stability when subjected to vibration.

either bulk production or laboratory use is shown in Fig. 5. This type of unit has been designed to overcome many of the disadvantages of previous assemblies and includes such features as the conical spring washer, which when depressed by the fixing bush, applies a predetermined pressure to the cup cores holding them firmly together without the additional use of an adhesive. The accessibility of the adjusting mechanism makes the assembly equally suitable for impregnation or resin casting, prior to a final adjusting operation.

6. Evaluation of the Design

6.1 Ferrite core. The practicable realization of such a range of components produces many difficulties, not the least of which are the tight mechanical limits required on the individual cup cores. Ferrites, with their inherent high shrinkage during manufacture, make it necessary to inspect 100% of the cores, while for maximum linearity of adjustment it is essential to ream the centre hole of a pair of cups, to maintain the cylindrical tolerances.

6.1.1 Practicable evaluation. Production-built filters have proved that the features described have been achieved in the Vinkor series. Filter coils have been wound and adjusted in approximately one-third of the time taken for an equivalent coil on the older fixed type of assembly, the bulk of the saving being in the reduction of operator's time when adjusting the final value of inductance.

7. Thermal Stability

The tests described below were designed to investigate the inductance stability of such components when subjected to daily temperature cycling.

7.1 Cores. Random production samples of 25 mm pot cores with effective permeabilities of 100, were selected for these measurements.

7.1.1 Coils. The coils were designed from the information given in Table 2 and after assembly, were adjusted to give their design value of inductance. Vacuum impregnation was carried out on two-thirds of the coils, Okerin type 561 wax (with a melting point of 83°C) being used for the assemblies with Ralsin (low water absorption Nylon) coil formers. For those with polystyrene coil formers, Okerin type 4148 wax (melting point 75°C) was employed. In the remaining dry assemblies the coil formers were fixed to one-half of the core with an epoxy-type resin.

7.1.2 Test procedure. The cores were cycled between 25°C and 70°C each day, and allowed to return to 25°C overnight ready for the following day's cycle. During weekends the temperature remained constant at 25°C. Inductance measurements were made at the same times, twice daily, the flux density in the centre core of each assembly being kept well below 5 gauss.

7.1.3 Conclusions. The results of these measurements are shown graphically in Fig. 6. The 25°C curves show clearly the now familiar thermal disaccommodation effect of the core material which arises when there is a sudden change in the rhythm of cycling. In general the curves show no apparent instability which can be attributed to the housing arrangement or adjusting mechanism.

8. Stability When Subjected to Vibration

8.1 Cores and coils. A similar set of 25 mm cores to those used in the thermal stability measurements were subjected to varying modes of vibration. All coils used were first bonded to one half of the ferrite and wax impregnated to reduce any effects due to turns slipping during the measurements.

8.1.1 Test procedure. Initial tests were carried out in accordance with B.S. 2011. The general result was that the inductance had increased by less than 0·01 % indicating a high degree of mechanical stability.

A second series of tests (details shown in Fig. 7) were made on the same assemblies after having disturbed the adjuster each time, to simulate initial adjustment conditions. The assemblies were divided into three groups and mounted on the working platform of an electromagnetic vibrator, in the manner shown below, and vibrated with a sinusoidal motion.

(i) Axis perpendicular to direction of vibration.
(ii) Axis parallel to direction of vibration (tag plate facing down).
(iii) Axis parallel to direction of vibration (tag plate uppermost).

8.1.2 Conclusions. The results of these measurements are shown graphically in Fig. 7 but also indicate a similar degree of stability. A resonance search did not reveal any frequency at which the assemblies or adjuster mechanism resonated.

Acknowledgments

Acknowledgments are due to Messrs. E. C. Snelling and N. C. O. Jackson who carried out the original design work, and Mr. T. Longhurst who carried out all measurements upon which this paper is based.

REFERENCES

(1) Duncan, and Stone, *Proc. Inst. Radio Engrs.*, **44**, No. 1 (1956).
(2) Bell, *S.T.J.* p.265 (1953).
(3) *Matronics* (N.V. Philips' Gloeilampenfabrieken), No. 6 (May 1954).

New Application for

Vapour-cooled Triodes

IN their new high-powered radio-frequency heaters, Redifon Ltd. have used English Electric BY1102 vapour-cooled triodes to provide the r.f. output power. There are two heaters, operating at 50 and 100 kW power output and at frequencies of 400-500 and 180-220 kc/s respectively. The 50 kW heater uses one BY1102 and the 100 kW heater used two BY1102 valves in parallel.

The technique of vapour-cooled high-power oscillator valves has been successfully established by service in the field and the advantages of this system have been proved conclusively in high-frequency heating generators. The water consumption required by the associated boiler units is approximately one-third that of conventional water-cooled valves.

As the outlet water temperature from the boiler units is higher than from jackets with conventional water-cooled valves, an air-to-water type heat exchanger can be used at a higher transfer efficiency. The boiler unit in the 100 kW equipment provides cooling facilities for both valves, in a twin assembly which has the remarkably low water flow of only 3·0 gallons per minute. Distilled water is used in the boiler to prevent the formation of scale on the valve anode.

These new heaters are designed especially for difficult induction heating loads requiring very loose coil coupling and high r.f. currents, such as in non-ferrous melting and heat treatment. The range of frequencies available enable these work loads to be heated very rapidly with the correct frequency chosen for each application. In addition, accurate case-hardening to very shallow depths can be achieved on items such as crank shafts and ring gears, which cannot be achieved at lower frequencies.

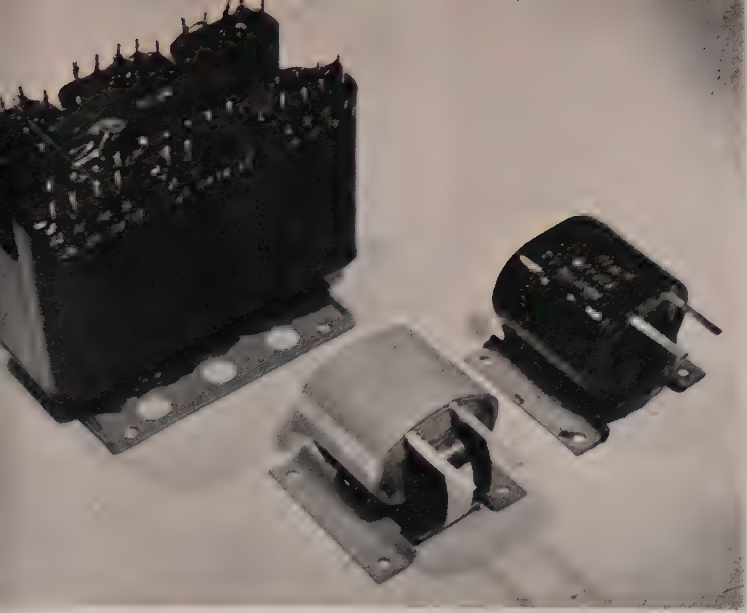
Texas Instruments Ltd.

Continued from p.577

In September 1960 a product-customer centre form of operating organization was put into effect. Two operating departments, one for the development, manufacture and distribution of silicon and germanium transistors and the other performing similar functions in the diode and rectifier area were established. The Manufacturing Services Department was formed and for the first time "quality assurance" was given departmental status at Bedford. The Marketing and Central Services Departments completed the organizational pattern of six departments responsible to Mr. A. Normand Provost who was appointed Managing Director at that time.

Towards the end of 1960, Texas Instruments Ltd. moved into its new Manton Lane plant. The building is thought to be the most modern semiconductor plant throughout Europe and has been designed to simulate laboratory conditions on a production basis.

The continual improvement of manufacturing methods and the increased application of mechanisation equipment have made possible very large-scale production of low cost semiconductor components. The product range is now stated to be the widest in the country including many silicon and germanium mesa devices. Texas Instruments Limited recently announced the first commercially available silicon epitaxial transistor to be produced in Great Britain, and many new devices are in various stages of development.



nsformers and chokes dip-coated with a coloured "Araldite" epoxy resin formula-
er being impregnated with an "Araldite" epoxy resin. The choke in the foreground
before and after this treatment.

EPOXY RESINS

In the Radio and Electronics Industry

By P. A. DUNN
CIBA (A.R.L.) Ltd.

Epoxy resins are used in many applications, since they not only possess a unique combination of properties, but they are available in many forms and can be used in a variety of ways. They are particularly valuable in the electrical industry because of their excellent electrical properties which make them very suitable as insulents. The combination of low moisture absorption, chemical resistance, toughness, durability, and excellent mechanical properties combined with the absence of volatile matter on curing, low shrinkage and the general ease of processing, are properties that also contribute to their success in this industry.

Introduction

EPOXY RESINS are available in a number of forms, some are solid, others liquid, while some are used in solution according to the application, but the basic principle of use is the same in every case. At a certain stage in the manufacturing process, a mixture of resin and hardener is brought to a liquid state, and then cured by chemical action to an infusible, solid insulating material. This action is carried out without the application of pressure and, in certain cases, without application of heat.

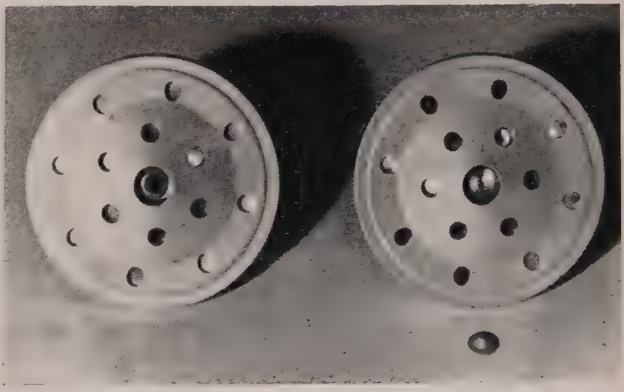
Within the electrical industry, the main processing techniques may be divided into six groups: casting, impregnating, laminating, bonding, moulding, and surface coating.

Cured epoxy resins possess excellent electrical properties, particularly in power and audio frequency ranges. Dielectric loss is less than that for porcelain, phenolics, and p.v.c., while volume and surface resistivity are higher.

The cured products are tough, durable and have good mechanical properties—for example, tensile and impact strengths are better than porcelain. They exhibit very low moisture absorption and their chemical resistance is outstanding. Other valuable characteristics include the absence of the evolution of volatile matter on curing, low shrinkage, and the ease whereby they are transformed by the chemical action from the uncured liquid to the cured solid state. This combination of properties makes epoxy resins extremely versatile and their field of use is already wide and still expanding. They are used not only as an improved alternative to more conventional materials, but also, and much more important, as the basis for new techniques and new concepts of design, particularly in the electrical industry.

The resins in the uncured state, ranging from viscous liquids to high melting-point solids, are thermoplastic with poor mechanical strength. They are converted into the hard, tough and substantially infusible materials of high molecular weight by reaction with a suitable hardener. A large range of chemical hardeners may be employed and include, acids, alkalis, as well as certain

Fig. 1. Steel pin bonded through the diaphragm using a hat-shaped aluminium pressing in conjunction with an "Araldite" epoxy resin adhesive system—*Ericsson Telephones Ltd.*



Epoxy Resin Ref. 'Araldite'*	CT200	CT200+ 200% Filler	MY753	
Hardener reference	901	901	951	97
Formulation (parts by weight)	"Araldite" CT200 100 Hardener 30	"Araldite" CT200 100 Silica flour 200 Hardener 30	"Araldite" MY753 100 Hardener 8-10	"Araldite" M Hardener
Form of resin	Solid	Solid + powder	Liquid	
Form of hardener	Powder	Powder	Liquid	Pow
Vapour pressure of hardener (mm. Hg)	(1) 2·8 at 120°C	(1) 2·8 at 120°C	<0·01 at 20°C	<0·01 a
Temperature of preparation of resin mix (°C)	120	120—150	Room temperature	10
Initial viscosity of resin-hardener mix at processing temperatures (poises)	1·4 at 120°C	55 at 120°C	20 at 20°C	100 at 8 at 2 at
Pot life (in hours) (3)	1½ at 120°C	1½ at 120°C	3 at 20°C 1 at 40°C ¼ at 60°C	38 at 8 at 3 at
Typical curing schedules (in hours)	16 at 120°C 10 at 140°C 8 at 160°C 2 at 200°C	12 at 120°C 9 at 140°C 6 at 160°C 2 at 180°C	24 at 20°C 6 at 40°C 3 at 60°C ½ at 100°C	20 at 4 at 1 2 at 1
Main applications	Casting and potting particularly in the heavy electrical engineering industry		Potting small components, etc., and bonding	Potting impregn
TYPICAL PROPERTIES OF CURED CASTINGS (4)				
Heat distortion temperature (°C)	100—110	110—125	50—70	100—
Specific gravity	1·2—1·3	1·7—1·8	1·2	1·2—
Flexural strength (1,000 p.s.i.)	19—20	14	12—15	14—
Tensile strength (1,000 p.s.i.)	9—12	9—12	8—11	8—
Compressive strength (1,000 p.s.i.)	16—17	27	14—15	14—
Modulus of elasticity (10^{6} p.s.i.)	0·5	1·8	0·45	0·45—
Coefficient of linear expansion (× 10^{-6}/°C)	60	32	90	80—
% Water absorption 10 days at 20°C 1 hour at 100°C	0·25—0·35 0·3	0·25—0·35 0·3—0·45	0·3—0·5 0·7	— —
Thermal conductivity cal/s/cm^{2}/°C/cm × 10^{-4} BTU/s/ft^{2}/°F/in. × 10^{-4}	4·7 3·8	14 11·4	—	—
Dielectric constant (temp. °C)	50 c/s 20° 3·84 10^{3} c/s 20° 3·70 10^{6} c/s 20° 3·62 10^{10} c/s 20° 3·01	50 c/s 20° 3·98 10^{3} c/s 20° 3·80 10^{6} c/s 20° 4·08	50 c/s 20° 3·9 10^{3} c/s 20° 3·72 60° 4·6 10^{6} c/s 20° 3·66	50 c/s 2 10^{3} c/s 2 6 10 10^{6} c/s 2
Power factor (tanδ) (temp. °C)	50 c/s 20° 0·002 10^{3} c/s 20° 0·009 10^{6} c/s 20° 0·028 10^{10} c/s 20° 0·022	50 c/s 20° 0·012 10^{3} c/s 20° 0·015 10^{6} c/s 20° 0·017	50 c/s 20° 0·015 10^{3} c/s 20° 0·017 60° 0·024 10^{6} c/s 20° 0·032	50 c/s 2 10^{3} c/s 2 6 10 10^{6} c/s 2
Volume resistivity (Ω—cm at 25°C)	6·5 × 10^{15}	6 × 10^{14}	6 × 10^{15}	3·8 ×
Dielectric strength (V/mil. short time, ⅛ in. section)	400—410		450—500	420

References (1) Effective vapour pressure of Hardener 901 is reduced by 50% when mixed with "Araldite" Resin B. Fillers still further reduce vapour press

(2) The pot lives quoted are for mixtures containing accelerator. Both pot lives and curing schedules may be varied over a wide range by proportion of accelerator.

* "A

Y205	MY750				
01	951	972	964 +accelerator	905 may be used with or without accelerator	906
CY205 100 40–45	**"Araldite" MY750 100 Hardener 10–12**	**"Araldite" MY750 100 Hardener 27**	**"Araldite" MY750 100 Hardener 130 Accelerator 0·5–2**	**"Araldite" MY750 100 Hardener 100 Accelerator if required**	**"Araldite" MY750 100 85 Accelerator 0·1–2·0**
		Liquid			
wder	Liquid	Powder	Liquid (Liquid accelerator)	Liquid (Liquid accelerator)	Liquid
120°C	<0·01 at 20 C	<0·01 at 20°C			
—120	Room temperature	10)	Room temperature	Room temperature	Room temperature
120°C	150 at 20°C	400 at 20°C 14 at 40°C 3 at 60°C	35 at 20°C 5 at 40°C 0·8 at 60°C	25 at 20°C 3·5 at 40°C 0·8 at 60°C	40-60 at 20°C 2 at 60°C
120°C	½—1 at 20°C	8 at 20°C 4 at 40°C 2 at 60 C	(2) 5-10 days at 20°C 1-2 days at 40 C 5-9 h at 60°C	(2) 5-10 days at 20°C 1-2 days at 40°C 5-9 h at 60°C	10 days at 20°C 8-16 h at 60°C
120°C 140°C 160°C 180°C	24 at 20°C 6 at 40°C 3 at 60°C ½ at 100°C	20 at 60°C ½ at 100°C 20 min. at 140°C 10 min. at 180°C	48 at 60°C 20 at 80°C 8 at 100°C 3 at 120°C	48 at 60°C 20 at 80°C 4 at 100°C 1 at 120°C	3-6 at 140°C 2 at 200°C
ng and gnating	Potting small components and bonding	High temperature resistant castings and laminates	Impregnating and potting	Impregnating and potting	High temperature resistant castings and laminates
—115	105	130—160	70—85	85—105	140—180
—1·3	1·2	1·2—1·3	1·2—1·3	1·2—1·3	1·2—1·3
—20	16—18	18—20	—	17—20	20
—8	8—9	8—9	5—7	5—7	8—10
16	15	16—17	12	18	16—17
·58	0·54	0·45—0·55	0·28	0·6	0·76
60	60	60—65	60	60	60
— —	— —	0·36—0·4 0·4	0·25—0·35 0·3	0·25—0·35 0·3—0·4	— —
·7 ·8	4·8 —	— —	— —	— —	— —
20° 3·86 20° 3·65 20° 3·60	50 c/s 20° 3·88 10^3 c/s 20° 3·86 10^6 c/s 20° 3·8	50 c/s 20° 4·3 10^3 c/s 20° 3·9 100° 4·0 130° 4·0 150° 4·1 10^6 c/s 20° 4·1	10^3 c/s 20° 2·8 60° 2·9 80° 3·3	50 c/s 20° 3·85 10^3 c/s 20° 3·6 80° 3·8 100° 3·8 10^6 c/s 20° 3·4	50 c/s 20° 3·30 10^6 c/s 20° 3·30
20° 0·002 20° 0·003 20° 0·023	50 c/s 20° 0·002 10^3 c/s 20° 0·012 10^6 c/s 20° 0·026	50 c/s 20° 0·002 10^3 c/s 20° 0·007 100° 0·004 130° 0·0075 150° 0·015 10^6 c/s 20° 0·025	10^3 c/s 20° 0·006 60° 0·012 80° 0·065	10^3 c/s 20° 0·009 80° 0·004 100° 0·005 10^6 c/s 20° 0·018	50 c/s 20° 0·008 10^6 c/s 20° 0·006
10^{15}	10^{15}	6×10^{16}	10^{14}	10^{15}	10^{16}
—415	400—450	450	400	400	400

References (3) Pot lives, particularly with Hardener 951 mixtures, show some variation with bulk.

(4) In many cases properties vary slightly with curing conditions.

le name.

more specialized substances. The type of hardener selected not only markedly affects the properties of the cured resin, but also affects the application viscosity of the mixture, the usable life, and the rate of cure, etc.

The many combinations and permutations of the several basic epoxy resins and the greater number of hardeners can be extended by even further modifications. The viscosity may be reduced by solvents or diluents or the end product made resilient by the use of plasticisers. Some diluents and plasticisers are reactive and can be combined into the final cured product. Diluents and plasticisers reduce viscosity or impart resilience at the expense of strength at elevated temperatures.

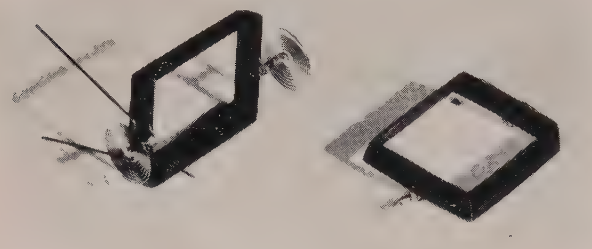


Fig. 2. An "Araldite" solution adhesive was used to bond these self-supporting coils in pyrometers, to form a rigid assembly—*Kelvin & Hughes Ltd.*

Inert fillers may be added to the epoxy resin system to give opacity, to improve hardness, wear resistance, thermal-conductivity, electrical and mechanical properties, to increase viscosity, to reduce the coefficient of expansion or possible exothermic reaction. Their use, of course, also reduces the cost of the end product. Commonly used fillers are silica, mica, chalk, metal and graphite powders, and asbestos, glass and synthetic fibres, etc. Epoxy resins can be dyed or pigmented, and pastes of colouring matter dispersed in liquid epoxy resin or plasticisers are available.

With these many possibilities of producing compounds, based on epoxy resins, that may be formulated to give properties to suit particular requirements, there is hardly an industry in which they do not find some application.

Adhesives

One of the earliest, and probably most well known use of epoxy resins, is as adhesives. If a brief consideration is given to some of the problems often encountered in the joining of materials by many well-known techniques, it can be shown that there is a need for alternative methods. For example, the high temperature of welding may lead to distortion in metal structures, and can also destroy the strength of light alloys originally achieved by careful heat treatment. Skilled work is often necessary to clean up the welds. Rivets and bolts may involve the use of holes, which lead to problems in making joints vacuum or pressure-tight. There is also the problem of electrolytic corrosion between different metals.

The negligible shrinkage and the ability to cure without evolving volatile or corrosive matter are important factors in the choice of epoxy resin adhesives. When cured, they are strong in their cohesive strength as well as in their strength of adhesion, thus they are capable of withstanding severe strain before breakdown, and are resistant to most environmental conditions. There is also the possibility of choosing, from the wide range of properties of different resin-hardeners systems, particular schemes to meet particular requirements. For example, resilient grades may be chosen for bonding materials of different coefficients of expansion, while the heavily filled solvent-free types may be used to fill the gaps between badly fitting components. Another important factor is their practical convenience in use.

The use of epoxy resin adhesives enables manufacturers to overcome the problems, mentioned earlier, that are associated with the conventional methods of joining. For example, the adhesives are processed at relatively low temperatures, thus avoiding distortion of metal parts, and joints can be made vacuum and pressure-tight. Replacing "shrink and fit" methods by an adhesive greatly reduces the problem of machining to close tolerances. The bonding processes themselves can usually be broken down into a number of relatively simple operations which, while requiring care, do not call for a high degree of skill, and can be carried out by easily trained labour.

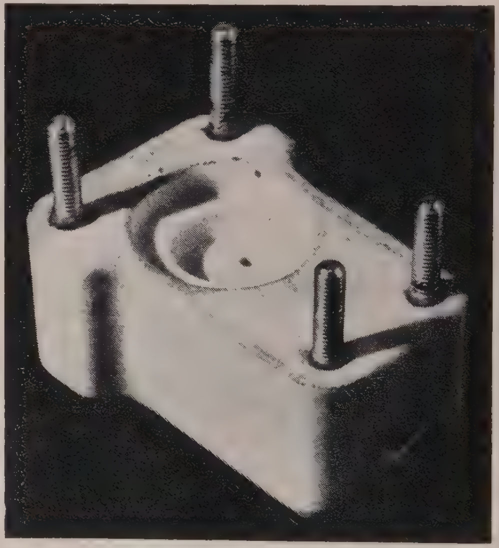


Fig. 3. Aerial insulator, fitted to radio set by four studs, showing the studs retained in the ceramic casting by means of an epoxy resin adhesive—*Murphy Radio Ltd.*

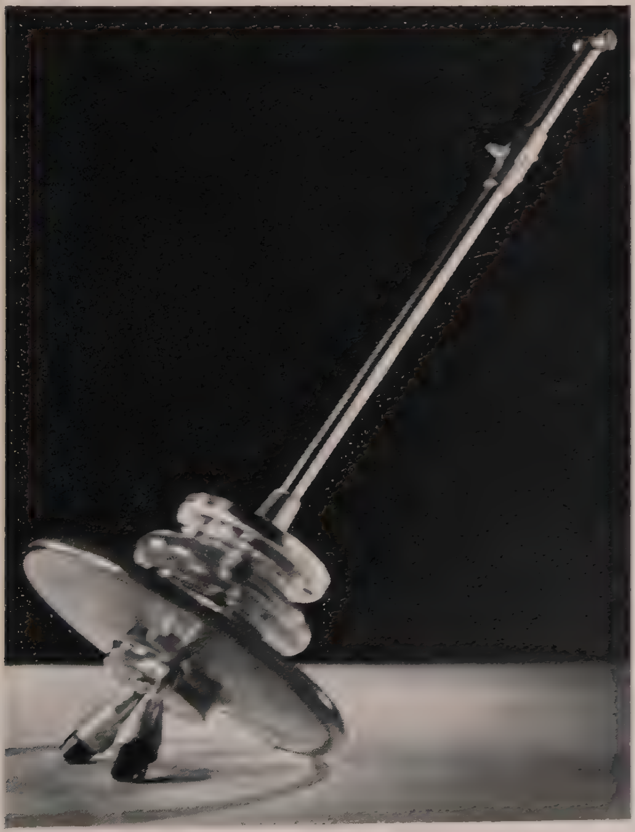
These adhesives are widely used and well established in the manufacture of components and assemblies within the radio and electronic industries. The following examples serve to indicate their even greater potential.

Use of epoxy resin adhesives in the electronics field. In the manufacture of iron dust cores, used for adjusting high frequency coils in electronic circuits, only one or two per cent of an epoxy resin is used to bond the iron powder firmly together. The electrical properties of the resin, as well as the adhesive quality are important in this application. In the production of microphones for recording apparatus, one Company was presented with the problem of passing a steel pin through the diaphragm and holding it permanently in position. This was solved by using a hat-shaped aluminium pressing in conjunction with an epoxy adhesive. The inside, as well as the flanges of the pressing, were filled with resin to provide a strong bond between the pressing and the pin as well as between the pressing and the diaphragm. Many ceramic insulators require to be fixed in position so that they may be removed at a later stage to facilitate servicing of the equipment. Threaded metal studs are often bonded to the ceramic component so that the whole assembly may be fitted in position by the use of nuts. Epoxy resin adhesives, often in the solution form to give thin glue lines, are used to bond self-supporting coils to form a rigid assembly. The wire is wound round a steel former, previously treated with a release agent so as to prevent the resin adhering to it, while the epoxy resin-hardener system is applied by brush. Many magnet assemblies are built up by the use of adhesives.

Casting Resins

Casting is the most important technique of the six methods of processing epoxy resins used within the electrical industry. It is in applications involving this process that epoxy resins are most widely used. Casting is mainly carried out by simple gravity techniques—the fluid, uncured mixtures being poured into moulds of metal, plaster, plastic or other material. There are three main types of application covered by the casting process: casting, potting and sealing. Although the term "casting" describes the general process, it usually implies the production of an insulating or insulated component where the mechanical as well as the electrical properties of the material are important.

Fig. 4. This shows an X-ray tube anode which consists of an "Araldite" epoxy resin insulator and support cast on to a central copper tube. The anode operates at 50 kV and at a very low pressure. The casting was carried out by *Messrs. McKinlay Electrical Manufacturing Co. Ltd.* for *Messrs. Hilger & Watts Ltd.*



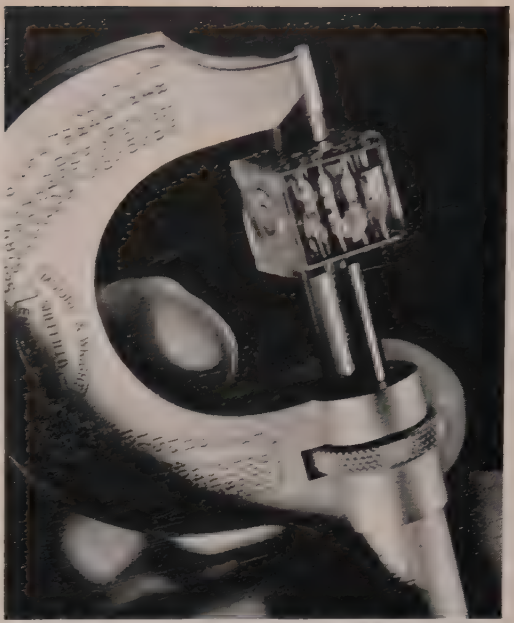


Fig. 5. A microminiature pre-amplifier unit, produced by *McMichael Radio Ltd.*, for use in telemetry equipment. The unit is encapsulated in "Araldite" epoxy resin.

Potting, or encapsulation, implies the complete envelopment and embedment of an electrical component or devices, in a protective mass of resin. The object of this is not only to insulate but also to protect the article being potted against vibration, shock, dust, ingress of moisture, chemical attack, and other environmental hazards. The term "sealing" within this context concerns more the completion of an existing enclosure of metal or insulating materials, surrounding an electrical device by casting the epoxy resin into the orifice.

The technique of protecting electrical components by enveloping them in a "block" or film of moisture-resistant material, was in use long before the development of the present-day potting or casting resins. For many years, components such as capacitors have been encapsulated in wax or bitumen, while transformers and other wound components have been impregnated, using vacuum or dipping methods. These processes, however, give very little mechanical protection to the components and in certain cases, have been known to degrade the electrical performance. Moreover, should any local overheating occur, thermo-plastic materials, such as wax and bitumen, will melt and drain away. Although many other materials have been tried, and a few (for example, polyesters, polyurethanes and butyl rubber)

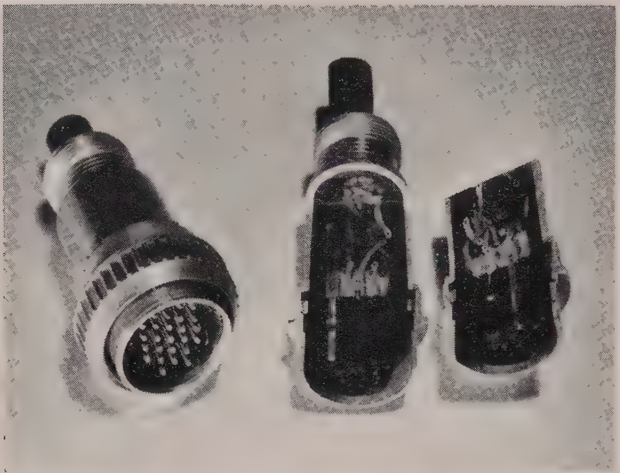


Fig. 6. Multi-way cable connectors, back-sealed with "Araldite" epoxy resin—*E.R.S. (London) Ltd.*

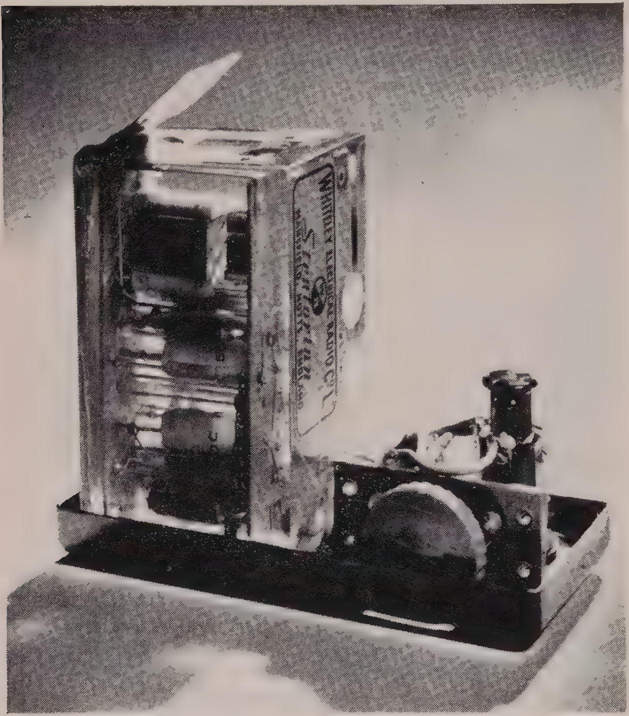
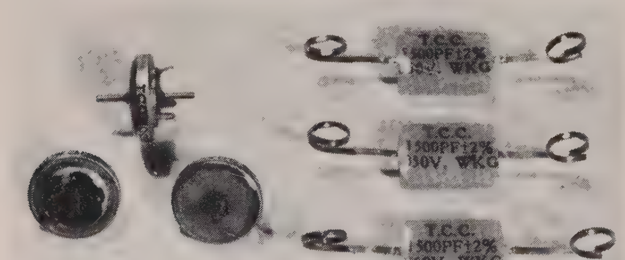


Fig. 8. Amplifier unit potted in an "Araldite" epoxy resin—*Whiteley Electrical Radio Co. Ltd.*

Fig. 10. Capacitors of stacked foil and mica construction and silvered mica capacitor elements potted in an "Araldite" epoxy resin system—*Telegraph Condenser Co. Ltd.*



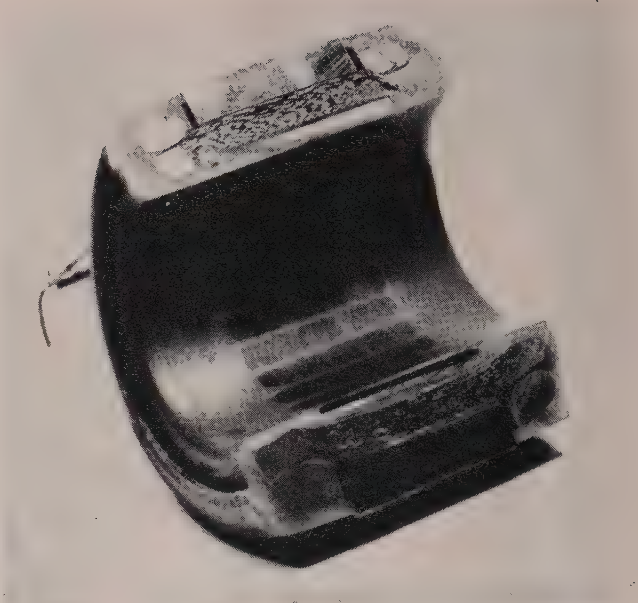


Fig. 7. Section of stator for submersible motor, cast by injection method—*CIBA Ltd., Basle.*

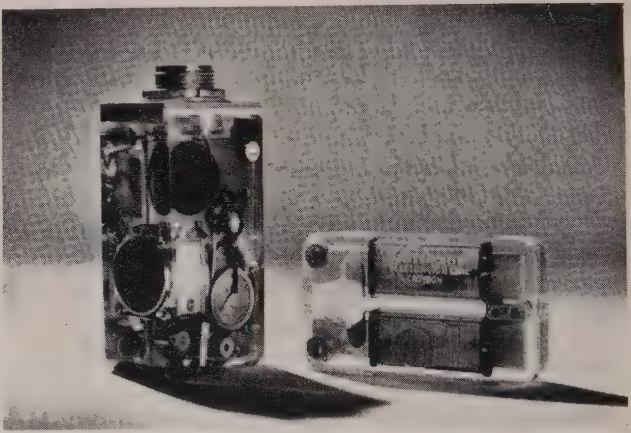
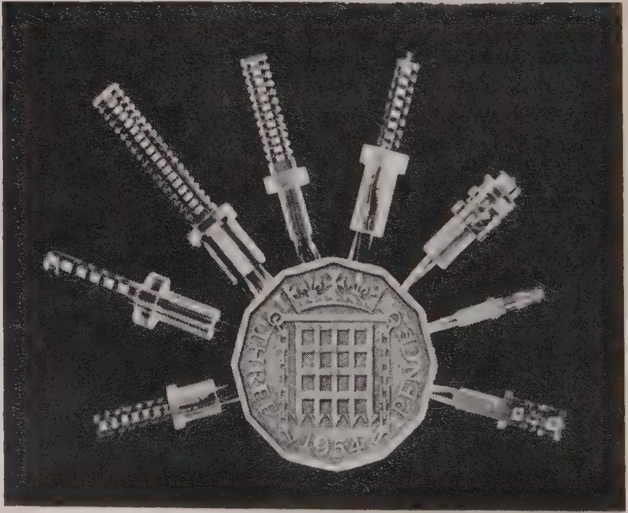


Fig. 9. 24 V transistorized oscillator solenoid pattern in "Araldite" resin—*Norbury Watch Co. Ltd.*

Fig. 11. Various miniature cylindrical slip rings made by *I.D.M. Electronics Ltd.* **with "Araldite" epoxy resin insulation.**



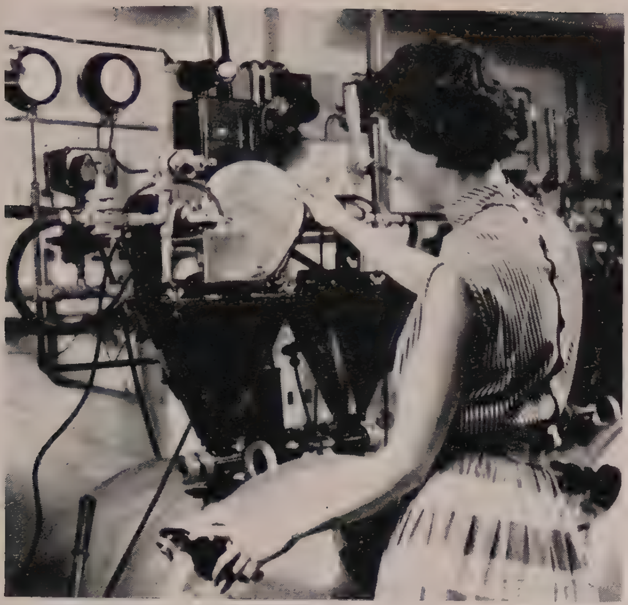


Fig. 12. Vacuum mixing and pouring plant for handling epoxy resins at *E. K. Cole Ltd.*

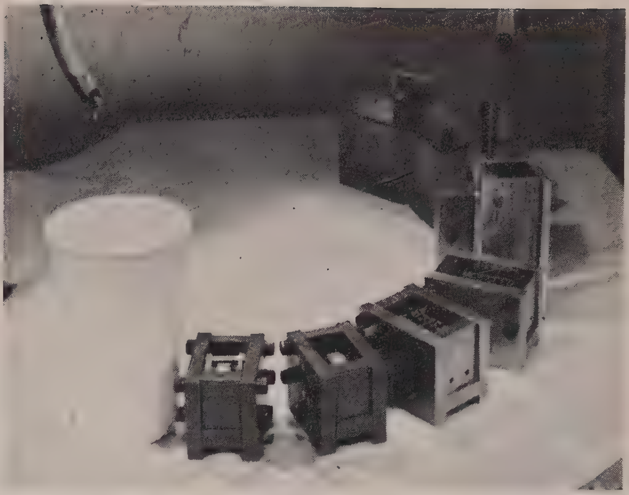


Fig. 13. In the main chamber of the vacuum encapsulating plant, the components in their mould are arranged in a semicircle on a turntable under the spouts from the mixing hoppers, also under vacuum. Watching through a window, the operator fills each mould with resin, moving the turntable so as to bring each component in turn under the filling spout—*E. K. Cole Ltd.*

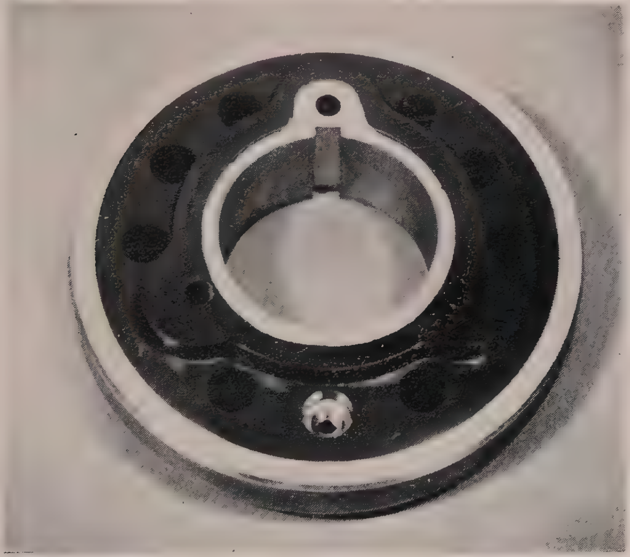


Fig. 14. Slip-ring made from "Araldite" moulding powder—*The Bushing Co. Ltd.*

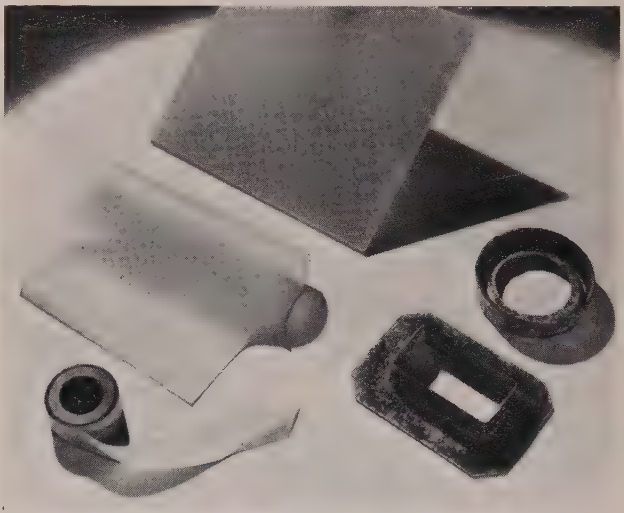


Fig. 15. Selection of laminates and impregnated tapes employing glass-fibre, synthetic fabrics and mica, etc.—with epoxy resins.

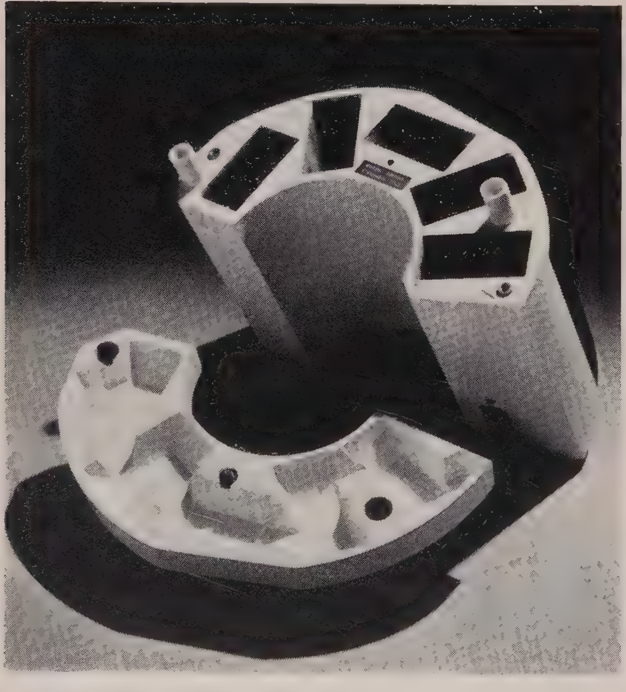
are still used to some extent, epoxy resins are outstanding for use in casting techniques, since their low shrinkage, absence of volatiles and excellent adhesion, have put them in a class apart. As in the case of adhesives, it is also possible to choose a resin-hardener system or a method of use to suit a particular application. Mixing and casting can be carried out under vacuum so that the resulting insulation may be free from voids. This is particularly important where steep potential gradients will be encountered as those which occur in most high voltage work. In some cases a sequence of vacuum and pressure techniques is used first to remove air and moisture and then force the resin mixture into the interstices of mould and the encast component.

In the manufacture of large castings the difference in thermal coefficients of expansion between resin insulation and metal components, may have to be considered. The already almost negligible shrinkage can be reduced to a minimum by choosing the most appropriate resin system and the most suitable curing schedule. Neither the curing shrinkage nor the thermal contraction cause much difficulty, unless inserts such as conductors, iron cores, etc. are included in the casting. Both the curing shrinkage and the thermal contraction can be further reduced by extending the resin mixture with inert mineral fillers. Silica, mica, slate and chalk, etc., are all commonly used and, by this means, the expansion of the resin can be halved and the problem greatly alleviated. At the same time, the use of fillers also reduces possible exotherm, increases the thermal conductivity and reduces the cost, thus it is the invariable practice to use fillers when making large castings. The exotherm and shrinkage may also be reduced to some degree by allowing the resin to gel at relatively low temperatures and completing the process by post-curing at a higher temperature. Because of the additional complication involved, this procedure is not generally desirable for large-scale production, and in any case it is not normally found to be necessary.

In some cases the resin may be plasticised or made resilient but care must be taken since the ultimate tensile strength is reduced and it may be reached before the material has extended sufficiently to take up the stress. Flexibilizers also reduce the performance of the casting at elevated temperatures. These methods are highly effective in ensuring successful operation under the most severe conditions. Only in the case of magnetic materials which are highly sensitive to pressure, such as some high permeability steels, is it necessary to exclude contact with the enveloping resin by making the core external to the casting or by other more specialized methods.

It is the field of power engineering and particularly in the manufacture of switchgear that epoxy resins have reached great commercial significance. Insulators and bushings made from epoxy resins are replacing the conventional porcelain and SRBP types. Epoxy resins can be cast into large, complicated and accurate shapes, and new designs can be evolved in which composite parts are cast together and unorthodox conductor arrangements used where clearances are kept to an absolute minimum. Current and voltage transformers, slip rings, commutators, rotors for vibrating electric hammers, and many other components are successfully potted in epoxy resins.

Fig. 16. Heated and insulated battery case moulded in an "Araldite" epoxy resin and glasscloth. Developed in conjunction with *E.M.I. Electronics Ltd.* for use in telemetry equipment in air-to-air missiles for the R.A.F.; it was made by *Martin Goacher & Co. Ltd.*



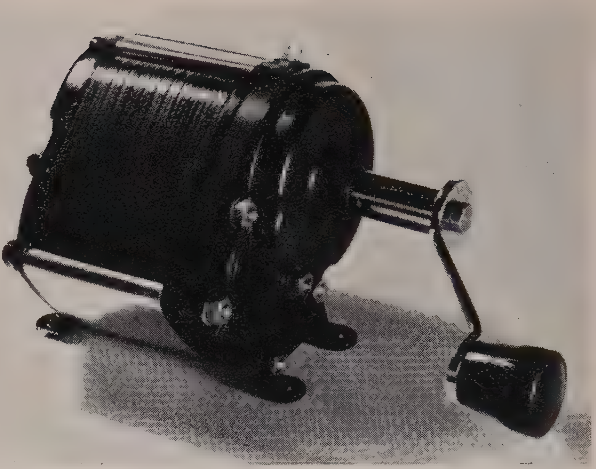


Fig. 17. An eggshell black stoving finish, based on "Araldite" 961A, was applied by hot dipping to finish and lock the laminations of this rotating magnet generator—*Ericsson Telephones Ltd.*

Within the term of "Casting", the process of potting or encapsulation is generally applied to electronic components and circuits and similar light electrical apparatus. Generally speaking, the same principles and procedure are adopted as in the manufacture of large castings, although there are one or two differences. For example, the epoxy resin systems employed within the electronic industry are not normally the same as in the heavy electrical industry. Since, as in many cases, components may be damaged by heat, room- or low-temperature curing systems are often employed. Single electric components are frequently potted separately, primarily to render them proof against moisture and other aggressive environments and quite often to give them better electrical performance and mechanical construction. Whole circuits or batches of components are also frequently potted. In this way, a unit of equipment can be cast into a single block, increasing the insulation strength, reducing the space required, and making the dielectric properties more constant. A block of components is easily replaceable in the event of failure of one of them, without the need for involved testing to locate the exact point of breakdown. Many components and circuits have been encapsulated successfully with epoxy resins and include resistors, capacitors, transistors, chokes, relays, and amplifiers etc. Although in the past, these applications have been confined to equipment for the Services, advantage is now being taken of these relatively new techniques in the electronics and radio industries. The photographs show some components that have been produced with the aid of epoxy resins. Fig. 5 shows a micro-miniature pre-amplifier unit, no larger than a 0·5 in. cube, which has been produced by McMichael Radio Ltd. for use in telemetry equipment. The unit is encapsulated in epoxy resin, which enables the use of very fragile components in a much smaller assembly giving a high input impedance and lower input capacitance than a unit produced by more normal techniques. An epoxy-"Thiokol" resin system is used to seal the back of the moulding and the cable ends of the multi-way cable connector shown in Fig. 6.

Another method of rendering components proof against moisture and other forms of environmental attack is to place them in cans which are sealed with a layer of epoxy resin. This technique may also eliminate the need for relatively expensive sealed outlet bushings.

Impregnating Systems

Epoxy resin systems, especially those employing anhydride hardeners, are particularly suitable for impregnation. These are solvent-free, low in viscosity and with their low shrinkage, absence of volatiles, and high adhesion, they are particularly attractive, enabling the finest windings to be fully impregnated. Some of the epoxy resin-anhydride systems need a relatively long curing time, but this may be reduced in many cases by the addition of a small amount of an accelerator to give curing cycles which compare favourably with the traditional phenolic based varnishes.

Solvent containing epoxy resin systems may also be used with advantage compared with more traditional systems. They may be used, for example, in impregnating and bonding "C"-cores, where the greatly superior adhesive properties of the epoxy resins justifies their use.

The usual technique used in impregnating with epoxy resins is the straightforward vacuum impregnation method in the industry. Vacuum may be followed by pressure where this is considered necessary.

The main application of the epoxy resin based impregnating systems in the electrical industry is in the impregnation of coils of different types, for example, relay coils, transformer windings and for impregnating paper condensers.

Moulding Powders

The introduction of epoxy resin moulding powders overcomes one of the difficulties associated with epoxy casting resins. Casting techniques are not always applicable when large quantities of small articles are required, because of the relatively low rate of production. The epoxy moulding powders, however, cure rapidly on the application of heat and pressure and mould easily with negligible after-shrinkage. They are very free-flowing and can be easily moulded round delicate inserts, while thin sections of resin may be moulded round large metal inserts without difficulty. As with other forms of epoxy resin, the absence of volatile matter during the curing operation is particularly valuable. Mineral and glass fibre filled products are available. The moulding powders should be stored in a cool place and if kept at a temperature of less than 25°C they have a shelf-life of about three months.

Epoxy moulding powders possess high insulation strength, good heat resistance, excellent dimensional stability, low water absorption and good resistance to tracking; they retain their dimensional stability at elevated temperatures and in adverse climatic conditions. Among their many applications may be mentioned their use in the manufacture of slip-rings for electric motors, as a replacement for a phenolic material which tended to crack due to shrinkage. They have also been used in the manufacture of high voltage bushings.

Epoxy resin based dough moulding compounds are also being developed.

Laminating

Glass fibre-reinforced plastics are in use in the electrical industry and although polyester resins are frequently used, since they are cheaper than the epoxy resins, the latter do provide laminates which are superior in certain respects. Epoxy resins adhere strongly to glass and have a small shrinkage. In consequence, epoxy resin laminates show a high degree of interlaminar adhesion and higher compression and flexural strengths than are obtained with conventional polyesters. Moduli of elasticity are also higher, and wet strength retention, particularly under load, and chemical resistance are outstanding.

The low shrinkage results in laminates with little internal stress, freedom from warping, and dimensional stability. The surface qualities of the laminates are excellent with absences of cracking or crazing and their electrical properties and their performance under fatigue conditions are equally as good.

The adhesive properties of epoxy resins enable composite assemblies to be made incorporating metal or other components in the laminate structure during manufacture. Both wet lay-up and dry lay-up techniques may be employed. In the wet lay-up technique, liquid resin mixtures without solvents are used to impregnate the cloth. In the dry lay-up technique, the glasscloth is impregnated with a solvent-based mixture of resin and hardener, the solvent dried off and the dried cloth stacked and cured under pressure at a later stage to form the required article.

In the heavy electrical industry, epoxy glass laminates are very suitable for switchgear components, such as operating rods, arc control pots and blast tubes for air blast circuit breakers. They are also used for coil formers, the insulation of slot liners of hydrogen-cooled alternators and various other components fabricated from sheet. Epoxy resin systems are finding use within the laminating field for the bonding of mica and integrated mica, where advantage is taken of their greater bond strength and improved electrical properties at high temperatures.

Surface Coatings

Epoxy resins are widely used in the manufacture of surface coatings. The combination of chemical resistance, adhesion, flexibility and hardness, etc., have put them in a class by themselves. The surface coatings industry has taken particular advantage of the fact that epoxy resins are capable of reacting with a large number of other materials and a wide range of air-drying and stoving finishes, as well as two-pack catalysed finishes are available. In the electrical industry the hardness, durability and resistance to moisture, tracking, and resistance to most chemicals are properties of particular value with respect to coatings based on epoxy resins. They have found application in the electrical industry in the form of varnishes, as surface coatings for insulators, and to a limited extent for wire enamels. The application of a surface coating of thicker section by the use of dipping compounds has been accomplished and this is a possible method of applying low voltage insulation and protective coatings for transformers, chokes, etc. Epoxy coatings have also been used as a solder resistant coating for printed-circuit boards. The additional insulation and protective value of the coating film is also of value in this application.

Conclusion

As will be seen, epoxy resins are firmly established in the radio and electronic industries. The above survey of their properties and applications indicates their even wider acceptance. Although the different forms of application have been described separately, it is of interest to note that the various forms of epoxy resin are often used in the manufacture of one piece of apparatus. Components may be, for example, bonded together, impregnated, cast in epoxy resin and the case of the final equipment protected with an epoxy resin paint. The use of epoxy resins in the manufacture of tooling may also be of interest to some sections of the electrical industry. Practically all forms of tooling for shaping metals and plastics can be made from epoxy resins as well as many forms of auxillary jigs and fixtures, etc. There are many other applications of the versatile epoxy resins such as in the production of fillers, chemical stabalizers, while they also find applications in the foamed or expanded form.

Future Articles on Plastics

Each month, until the end of 1961, it is intended to publish at least one article on the applications of plastics or plastic compounds in the electronic components field. In our next issue will be published an article entitled "Encapsulation Systems for Electronic Components". Each article will contain valuable tables and helpful photographs illustrating specific applications.

Hermetically-sealed Nickel-cadmium Accumulators*

By Dipl. Ing. K. Dehmelt

Hermetically-sealed Ni-Cd alkaline accumulators are enjoying increasing popularity in increasing fields of application in the electrical and electronic industry. Up to now very little has been published about their operation. Their development was a logical evolution from the open type alkaline cell, the obstacles hitherto having been to find a way of avoiding hydrogen formation and to convert the evolved oxygen so that no gas pressure builds up, even during overcharge. The cells now available are operationally safe not only against reasonable overcharge but also against polarity reversal due to over-discharge down to zero volts.

Whilst the open types of nickel-cadmium accumulators have been used extensively in ever-increasing quantities for many years, the hermetically-sealed nickel-cadmium accumulators have only been available for a few years. The main advantages of sealed accumulators are that they do not require maintenance, the electrolyte need not be renewed or replenished, and the accumulators may be used in any position. These advantages have resulted in millions of cells being used in a large variety of applications. The following article explains the operation of these cells. As introduction to the electro-chemical reactions which occur, the open type nickel-cadmium accumulator is dealt with first.

ELECTRO-CHEMICAL REACTIONS IN THE OPEN NICKEL-CADMIUM ACCUMULATOR USING LIQUID ELECTROLYTE

The positive electrode of the nickel-cadmium accumulator in the uncharged state consists of nickelous hydroxide Ni $(OH)_2$; in the charged state of the higher hydroxide NiO (OH). The active substance of the negative electrode, in the uncharged state, is cadmium hydroxide Cd $(OH)_2$, which on charging becomes finely distributed metallic cadmium. As a rule a conducting material (e.g., nickel or graphite) is added to both electrode substances. This serves to improve electrical conduction within the active substances and increases mechanical strength.

The electrolyte, mutual to both electrodes, consists of potassium hydroxide. Separators prevent direct metallic contact between the electrodes.

On the one hand, the electrolyte ionises and the electricity is conducted through the electrolyte by the ions only. On the other hand it is conducted through the metal by free electrons. Therefore we can, by neglecting the less important side and intermediate reactions, represent the charging and discharging processes by the following equations.

For the positive electrode:

$$2Ni(OH)_2+2OH^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} 2NiO(OH)+2H_2O+2e^- \quad . \; . \; (1a)$$

It will be seen that during charging, reaction going from left to right, two free electrons occur.

For the negative electrode:

$$Cd(OH)_2+2e^- \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} Cd+2OH^- \quad . \; . \; . \; . \; (2a)$$

Charging requires the addition of two electrons and discharging the subtraction of two electrons. Equations (1*a*) and (2*a*) may be combined to give:

$$2Ni(OH)_2+Cd(OH)_2 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} 2NiO(OH)+Cd+H_2O \quad . \; . \; (3a)$$

It is immediately evident that electrolyte (KOH) does not appear in the reaction and that water is produced when charging and is taken up again when discharging. Provided plenty of electrolyte is present the fluctuation in water content has very little effect on the operation of the cell.

The above equations are valid for as long as there are active substances on the electrodes which have not taken part in the charging or discharging operation. If, in the process of prolonged charging, all the uncharged material present is charged the electrodes are then not able to accumulate charging current. Since the capacity or load capacity of the negative and positive electrodes can differ then the following reactions will occur.

Overcharging of the positive electrode

$$2(OH)^- \rightarrow \tfrac{1}{2}O_2\uparrow+H_2O+2e^- \quad . \; . \; . \; . \; . \; (1b)$$

---

* **This article was first published in Germany in *E.T.Z.*, Edition B, 12, No. 1 (11th January, 1960). Readers should note that DEAC hermetically-sealed nickel-cadmium accumulators are now being manufactured in Great Britain and the sole distributors are G. A. Stanley Palmer Ltd., Maxwell House, Arundel Street, Strand, London, W.C.2.**

i.e. oxygen is given off at the positive electrode on overcharging. If the negative electrode should still contain uncharged masses then equation (1*b*) must be combined with equation (2*a*).

Overcharging of the negative electrode:

$$2H_2O + 2e^- \rightarrow 2(OH)^- + H_2\uparrow \;.\;.\;.\;.\;.\; (2b)$$

i.e., hydrogen is given off at the negative electrode on overcharging. If the positive electrode still contains uncharged masses, then equation (2*b*) must be combined with equation (1*b*).

Combining (1*b*) and (2*b*) gives:

$$H_2O \rightarrow H_2\uparrow + \tfrac{1}{2}O_2\uparrow \;.\;.\;.\;.\;.\;.\;.\; (3b)$$

thus if both electrodes are fully charged hydrolysis occurs.

PROBLEMS OF HERMETICALLY-SEALED ACCUMULATORS

If an open type accumulator is firmly sealed, so that it is gas and liquid tight, without special precautions being taken, then overcharging will result in hydrogen and oxygen gas being evolved as per equation (3*b*) above. These gases will result in a pressure build-up which will, in turn, cause the cell casing to swell and eventually explode. It has been shown experimentally that the hydrogen evolved from the reaction according to equation (2*b*) can only be contained or absorbed with difficulty. On the other hand, the oxygen formed due to reaction (1*b*) can be absorbed by the negative electrode; provided that it is ensured that the oxygen formed at the positive electrode has means of getting to the negative electrode. This transfer of oxygen from positive to negative electrodes can be effected by ensuring that all the electrolyte is held in the pores of the electrodes and porous separator.

In order to avoid hydrogen being evolved during overcharge it is essential that the positive electrode exhausts its ability to absorb further charge, whilst the negative electrode still has an amount of uncharged cadmium hydroxide. This surplus amount of cadmium hydroxide is called the charging reserve of the negative electrode.

The proportioning of the electrodes is shown in Fig. 1. The significance of the charging reserve becomes evident when we consider that, once the positive electrode is completely charged, oxygen is evolved. The oxygen reaches the negative electrode *via* the separator where it is changed into hydroxyl ions; the overall equation being:

$$\tfrac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2(OH)^- \;.\;.\;.\;.\;.\; (1c)$$

It is seen that this equation is the reverse reaction of equation (1*b*). The active mass of the negative electrode does not enter into the equation. We must, therefore, conclude that the electrons conducted to the negative electrode (overcharge current) are used up producing hydroxyl ions by reaction with the supply of oxygen and water at the metallic, conducting surface of the electrode.

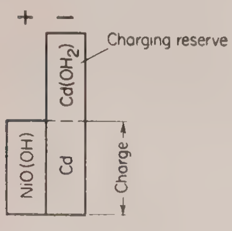


Fig. 1. Charging reserve prevents formation of hydrogen.

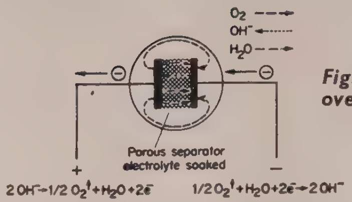

O_2
OH^-
H_2O
⊖
⊖
Porous separator electrolyte soaked
+
−
$2OH^- \rightarrow 1/2\,O_2\uparrow + H_2O + 2\bar{e}$
$1/2\,O_2\uparrow + H_2O + 2\bar{e} \rightarrow 2OH^-$

Fig. 2. Oxygen circulation when overcharging.

Fig. 2 shows schematically the circulation of oxygen during overcharging. For this oxygen circulation to run smoothly it is essential that the amount involved should be small, depending on overcharging current and the physical construction of the cell.

If overcharging stops by switching off the current the free oxygen in the cell continues the reaction at the negative electrode. The negative electrode itself supplies the necessary electrons and some of the metallic cadmium is oxidised to $Cd(OH)_2$ [combination of reactions (1*c*) and (2*a*)]. The oxygen pressure is, therefore, decreased and, after at short time, there can even be a vacuum pressure in the cell.

Summarizing, therefore, we can say that, on charging, the results are the same as for open type accumulators provided both electrodes still contain uncharged particles—except that when the positive electrode is charged completely the oxygen circulation shown in Fig. 2 takes place. An adequate charging reserve ensures that hydrogen is not formed at the negative electrode.

When cells are used in a series battery it is possible that during discharge, because of differences in capacities, some cells will undergo a reversal in polarity whilst other cells continue to supply current. If no special precautions are taken then over discharging with reversed polarity can also result in gas forming at the electrodes. In order to ensure that there is not an excess pressure build-up in this case, the principle of the charging reserve is applied in the same manner for discharging. This is done by supplying the positive electrode with an amount of negative active substance. This portion, being described as the antipolar mass, does not disturb the normal functions of the positive electrode during charging and discharging, since it exists, in this case, as electro-chemically ineffective cadmium hydroxide. Only when the cell changes polarity, due to over-discharging, is the cadmium hydroxide reduced to cadmium for as long as oxygen is formed at the completely discharged, normally negative electrode. The oxygen is then used up at the normally positive electrode. An appropriate electrode arrangement is shown schematically in Fig. 3.

Thus, with the help of the charging reserve of the negative electrode and antipolar mass on the positive electrode we have a battery system capable of withstanding overcharging and overdischarging.

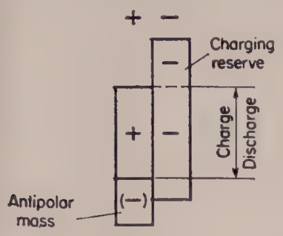


Fig. 3. Proportion of charging reserve and antipolar mass.

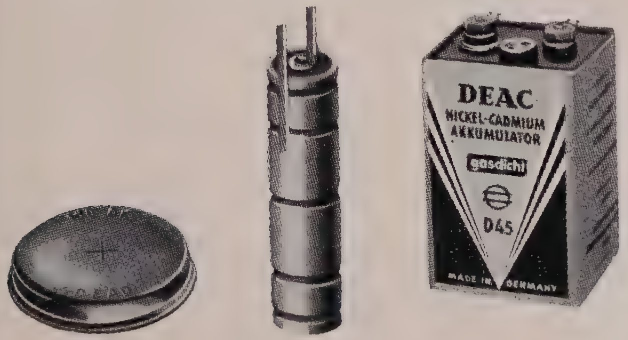
DIFFICULTIES ENCOUNTERED IN ESTIMATING THE AMOUNT OF ELECTROLYTE TO BE USED

Although the formation of water during charging and removal of water during discharging (equation 3*a*) does not play an important part in an open cell, the resultant changes in concentration become very significant in the hermetically-sealed accumulator with its relatively small amount of electrolyte. It should be regulated so that the electrolyte strength remains sufficiently conducting and the characteristics necessary for oxygen circulation are not lost. It should be appreciated that opening the cells and changing the electrolyte is both unnecessary and inadvisable since it could result in the cells not functioning.

When overcharging a hermetically-sealed cell it is essential that the current must not exceed a predetermined amount. The higher the overcharging current the greater the gas pressure in the cell, i.e. more oxygen requiring to be circulated. As a guard against any danger which may arise from maltreatment a pressure release valve has been incorporated in the larger hermetically sealed cell types.

The amount of energy converted to heat during overcharging is greater than that produced in an open-type cell. In the open type the evolved gases escape during overcharge but in the sealed cell the whole of the energy has to be converted to heat. It should not be assumed that overcharging results in a higher internal resistance of the cell due to the evolution of heat. The heat is evolved mainly due to the conversion of oxygen into hydroxyl ions. On the contrary, the internal resistance is very low, a characteristic of value in circuits where it is desired to suppress an a.c. component superimposed on d.c., i.e. for smoothing purposes. Since the a.c. impedance is only very slightly frequency dependent, compared to a capacitor, a sealed Ni-Cd cell offers particular advantages as a filter component for low and very low frequency use.

Fig. 4. Three different designs of hermetically-sealed cells.



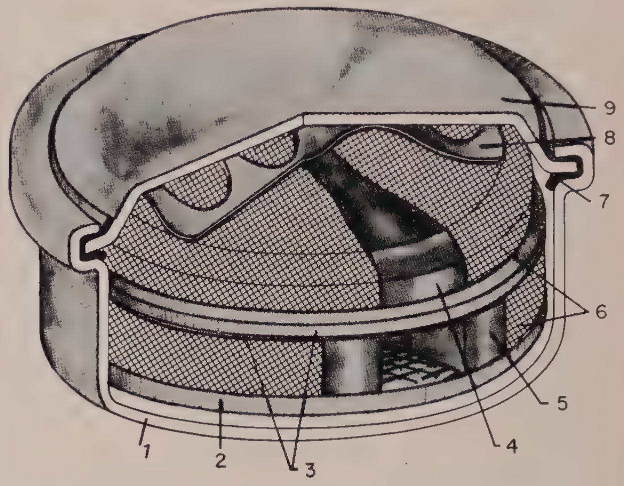


Fig. 5. Section of disc-type cell.

1 Cell cup
2 Bottom insert
3 Separator
4 Negative electrode
5 Positive electrode
6 Nickel wire gauze
7 Sealing washer
8 Contact spring
9 Cell cover

Hermetically sealed Ni-Cd accumulators are produced in four different designs at the present time (Figure 4):

1. As button cells of small capacity from about 20 to 450 mAH (Fig. 5),
2. As cylindrical cells of medium capacity from about 450 mAH to 2 AH and
3. As rectangular cells from about 1·5 AH upwards.

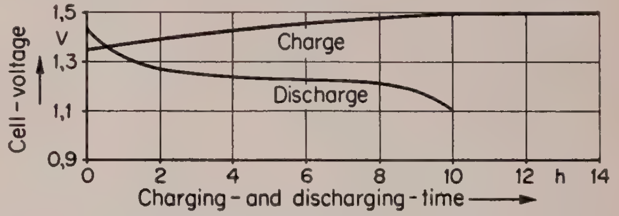


Fig. 6. Voltage characteristic when charging and discharging the disc-type cell 450 DK with 45 milliamperes.

In addition to the designs of sealed cells described above, developments have been made of cells having sintered plates and these will go into production shortly in button, cylindrical and rectangular design. The electrodes of these cells consist of a highly porous sintered plate to which the active masses are applied. Cells with sintered electrodes have an extremely low internal resistance and these have a high load capacity as well as improved power to weight and power to volume ratios.

Fig. 6 shows the charge/discharge voltage curve of a 450 mAH button type cell (Type 450 DK) at 45 mA charge and discharge current (10 hour discharge rate).

NEW BOOKS

Advances in Electron Tube Techniques

Edited by David Slater
235 pp. Pergamon Press Ltd. Price £5

THIS volume contains the text of 44 papers which were presented at the Fifth U.S. National Conference on Advances in Electron Tube Techniques, held in September 1960. As the title of the Conference implies, these papers are from American sources, the one exception being an invited contribution giving a survey of new vacuum apparatus developed in Europe. However, many of the authors are well known for their previous published work, and these Conferences, which are held every two years, give a valuable opportunity for the exchange of ideas.

Taken as a whole, these proceedings give a broad picture of progress towards smaller, more efficient electron tubes, designed to withstand onerous working conditions with longer lives. Individually, they give details of research and investigation into problems that have long been the concern of engineers throughout the world.

No less than 18 papers deal with the properties and possibilities of various types of cathode material and cathode construction, while another seven discuss the individual and collective characteristics of various new glass/metal/ceramic materials for vacuum envelopes. The remaining papers spread widely over the Conference subject, dealing with topics ranging from rare metals and getters to designs for rugged image orthicons and small size power tubes.

This book will form a valuable addition to the library of any organization interested in this subject, and engineers engaged in this work are sure to find in it several papers of absorbing interest. The volume is well printed, with serviceable binding, and there is a useful index which is a welcome addition to such a collection of papers.

A. J. T.

A Modern Russian Reader for Technical College Students

By N. S. Fudel'
134 pp. Pergamon Press Ltd. Price 35s.

IN recent years, the choice of Russian as a second (or third) language by English-speaking students has gained ground over the traditional claims of French and German. With the dramatic rise of the U.S.S.R. as a great industrial power, it is to be expected that an increasing number of science and technical students will come to regard a knowledge of the Russian language as an essential auxiliary to their main studies.

This compact little volume is a notable addition to the somewhat limited reading material available to such students and has, in fact, been custom-built for their requirements. It covers very successfully, in a series of concise essays of convenient length to busy students, a wide variety of interesting topics and aspects of Soviet life. Though heavily flavoured with industrial and technological subjects, the essays are very readable and informative throughout.

From the point of view of grammar, the book is unlikely to afford any serious difficulty to the diligent reader with one or two years grounding in the language, and with the special needs of technical students always in view, provides a considerable wealth of technical vocabulary and expressions, unusual in a book of this size and scope. The vocabularies might, with advantage, have been included at the end of each essay to avoid references. This is, however, a small fault in an otherwise excellent book.

E. Doherty

The Antenna

By L. Thourel
Translated from the French by H. de Laistre Banting
400 pp. Chapman and Hall Ltd. Price 70s.

THE Author's Preface to this book states that it is essentially a manual for use in planning an antenna system to specific requirements, written for engineers and technicians who need an introduction or a precis of information on antenna techniques with the minimum of complicated mathematical arguments: the author hopes that the book will fill a gap in the French literature, which contains few works on antennas. The first half of the text is devoted to metre wave antennas, including vertical antennas and half-wave dipoles, beamed transmission from groups of radiators and arrays of dipoles, rhombic antennas and end-fire antennas (with a section on the "cigar" aerial of Simon and Weill). The second half deals with microwave aerials, with chapters on electromagnetic horns, paraboloids, cosecant-square antennas, slot aerials and electromagnetic lenses. It is regrettable that the book's usefulness as an introduction to antennas for English readers is seriously marred by the use of terminology which is often non-standard (e.g. "equivalent receiving surface" for "effective receiving area"), and in one instance misleading ("aperture" for "beamwidth"—although "aperture" is used for "aperture" also): in this respect the author has not been well served by his translator. Readers who are already familiar with the standard works of S. Silver and J. D. Kraus will be able to interpret the translator's terminology, but will have little need to acquire this additional text.

H. Gent

NEW COMPONENTS

New STC Components

New, medium-power silicon diodes, a new reference diode, a new range of capacitors and additions to existing ranges of STC valves, transistors and magnetic materials are announced by the Components Group of Standard Telephones and Cables Ltd.

Medium-power silicon rectifiers. An addition to the RS series of medium- and high-power silicon rectifiers is announced. Designated RS600, these new devices are rated at 25 A mean, and 100 to 600 V crest working voltage at 125°C maximum stud temperature. Maximum dissipation is 30 W.

These rectifiers are available either stud positive or stud negative, and suitable heat sinks to give full rating with natural air cooling at ambients up to 40°C can be supplied.

REC 101 *for further details.*

Stantelac capacitors. A new range of Stantelac (synthetic dielectric) capacitors has the same electrical characteristics as the existing range but is more robust and results in a reduction in selling price.

The following table lists the dimensions and ratings of capacitors in the new range:

DIMENSIONS AND RATINGS OF STANTELAC CAPACITORS

Working voltage (d.c.)	Capacitance (F)	Maximum dimensions*				Code
		Length		Diameter		
		in.	mm	in.	mm	
50	0·01	0·67	17·0	0·155	3·94	489/LWA/41BA
	0·022	0·78	19·8	0·155	3·94	42BA
	0·047	0·67	17·0	0·207	5·26	43BA
	0·1	0·78	19·8	0·207	5·26	44BA
	0·22	0·78	19·8	0·287	7·29	45BA
	0·47	1·09	27·7	0·287	7·29	46BA
	1·0	1·35	34·3	0·432	10·97	47BA
	2·2	1·35	34·3	0·570	14·48	48BA
100	0·0047	0·67	17·0	0·155	3·94	489/LWA/41CA
	0·01	0·78	19·8	0·155	3·94	42CA
	0·022	0·67	17·0	0·207	5·26	43CA
	0·047	0·78	19·8	0·207	5·26	44CA
	0·1	0·78	19·8	0·287	7·29	45CA
	0·22	1·09	27·7	0·287	7·29	46CA
	0·47	1·35	34·3	0·432	10·97	47CA
	1·0	1·35	34·3	0·570	14·48	48CA

* *Dimensions quoted are over insulating sleeving.*

REC 102 *for further details.*

	TK 200A	TK 201A	TK 250A	TK 251A	Unit
f_T (min) at 20 Mc/s ...	50	100	50	100	Mc/s
h_{fe} (min) ($I_C=20$ mA $V_{CE}=9$ V)	8	20	8	20	
Dissipation	3	3	0·6	0·6	W
V_{CB} *max*	40	40	40	40	V
V_{CE} *max*	20	20	20	20	V
V_{EB} *max*	6	6	6	6	V
I_C *max*	0·5	0·5	0·25	0·25	A
I_E *max*	0·6	0·6	0·285	0·285	A
Outline	SO-5 TO-3	SO-5 TO-3	SO-3 TO-9	SO-3 TO-9	

All types are available in sample quantities.

Silicon diffused mesa transistors. There are now four devices in the available range of STC silicon diffused mesa transistors. They fall into two categories according to their case outlines, the TK200A and TK201A being accommodated in the JEDEC TO-3 case (i.e. conforms to VASCA outline SO-5 and base SB2-2) and the TK250A and TK251A in the TO-9 case (i.e. conforms to VASCA outline SO-3 and base SB3-4). The above table gives brief data; fuller information is available on request.

REC 103 *for further details.*

New germanium diodes. Full production of three new germanium gold-bonded diodes is announced. Coded DK13, 14 and 15 they are similar to the existing diodes DK10, 11 and 12 respectively but have improved characteristics. For example, the maximum charge storage figure for each type is 6×10^{-10} coulombs, while the minimum forward current at 1 V is 100 mA. The maximum reverse voltage ratings are as follows:

DK13: 50 V
DK14: 80 V
DK15: 100 V

The low storage and junction capacitance characteristics make these diodes ideal for fast switching circuits.

STC gold-bonded diodes are sealed in miniature glass envelopes and have a double-ended coaxial configuration.

REC 104 *for further details.*

Magnetic materials—Stanferite range expanded. The range of "Stanferite" magnetic materials has now been expanded and recoded. Details of the manganese-zinc, nickel-zinc and mixed ferrites in the range are given below.

Details of the new method of coding, devised to simplify ordering procedure, are given in the current edition of *Components News*, copies of which are available on request.

Stanferite SA400 is a medium permeability manganese-zinc ferrite material having low losses and a low temperature coefficient of permeability. This material is suitable for high-grade stable inductors, pulse transformers, etc., and can be used in tuned applications up to approximately 1 Mc/s. Higher frequencies may be used in certain non-tuned applications.

Stanferite SA600 is a high permeability manganese-zinc ferrite material having low losses and a low temperature coefficient of permeability. It is suitable for wide-band transformers, low and audio frequency stable inductors, hybrid transformers, recording heads, etc., and can be used in tuned applications up to approximately 500 Kc/s. Higher frequencies may be used in certain non-tuned applications.

Stanferites SB300, SB400, SB500, SB600 and SB700 are nickel-zinc ferrites of lower permeability, low dielectric constant and very high resistivity, suitable for transformers and similar applications. The permeability and frequency range for the respective types are as follows:

Type	Initial permeability (Nominal)	Frequency range
SB300	15	10 Mc/s to 150 Mc/s.
SB400	30	1 Mc/s to 50 Mc/s.
SB500	100	500 Kc/s to 15 Mc/s.
SB600	200	200 Kc/s to 5 Mc/s.
SB700	650	50 Kc/s to 2 Mc/s.

Stanferites SC300 and SC500 are mixed ferrites having rectangular hysteresis loops and rapid switching characteristics for use in data storage and computer applications. SC300 is suitable for storage or switching and is usually supplied in the form of micro-toroids but can be supplied in toroids up to a maximum dimension of 0·47 in. SC500 is suitable for coincident current memory matrices. It is usually supplied in the form of micro-toroids, but can be supplied in toroids up to a maximum dimension of 0·47 in.

REC 105 *for further details.*

Stanferite cores. STC offer a comprehensive range of pot, ring and U-cores in several of their Stanferite materials.

The present range of Stanferite air-gapped pot cores is provided with a minimum inductance adjustment of −3% or −5% to +5%. This is achieved by rotating one-half of the pot core relative to the other, and is produced by an asymmetric air gap resulting in a flux distortion. This is primarily used to compensate for the spread in capacitor and other component tolerances associated with the inductor, without recourse to mechanical adjustment of the air gap, and in so doing enables a standard number of turns to be used.

Power triode. Owing to commercial demand, the air-cooled version (code 3J/252E) of the 48 kW output industrial triodes, designed for operation from a 12 kV supply, is being restored to the current range; it now has a modified radiator designed for a maximum dissipation of 12 kW. A new version (code 3R/252E) with an integral coiled water jacket is announced. This valve has a maximum anode dissipation rating of 14 kW.

The other two valves in this series are:

Water-cooled version 3Q/252E
and Vapour-cooled version 3Z/252E.

both with a maximum rated dissipation of 24 kW. The vapour-cooled version has a high factor of safety in this respect. All of these valves have an amplification factor of 24.

REC 106 *for further details.*

7½ W Zener diode. A new reference diode, capable of dissipating 7½ W when used with an appropriate heat sink covers the range 6·8—50 V with 5% tolerance. These silicon Zener diodes are manufactured using diffusion techniques and have a particularly low slope resistance. The maximum operating stud temperature is 125°C, allowing the minimum heat sink size. This extension of the SenTerCel range of Zener diodes will enable designers to use this circuit element for higher power voltage regulators, references, limiters and couplers.

REC 107 *for further details.*

Communication power triodes. The need has arisen for a power valve similar to the 3J-Q-R-Z/252E series but with characteristics more suitable for linear amplifier applications. The modified valve is available in air-, water- or vapour-cooled versions under codes 3J/253E, 3Q/253E and 3Z/253E respectively and has linear characteristics and an amplification factor of 36. Its maximum ratings and cooling requirements are similar to the corresponding industrial versions. This new range does not replace the earlier range for industrial applications since the grid dissipation safety factor is lower, but this is of no consequence for constant drive, constant load, conditions.

REC 108 *for further details.*

Precision Switches

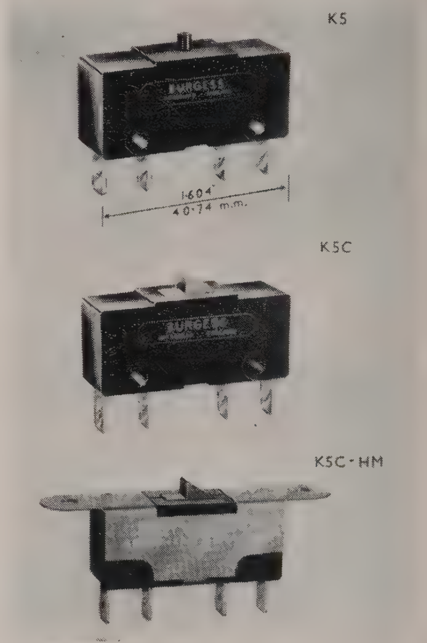
The main features of the "K5" Series of precision switches, which have just been released by Burgess Products Co. Ltd., can be summarized as follows:

Electrical rating. To cater for the increased loads becoming popular in the domestic appliance industry and in certain other branches of engineering, Burgess "K5" switches have been given the exceptionally high rating of 25 A at 250 V a.c. on resistive loads. Other ratings are: 15 A at 440 V a.c. resistive load, 15 A at 250 V a.c. inductive load, 0·5 A at 250 V d.c. resistive load. The K5 series are thought to be the only precision, snap-action switches in the world to be rated so high and yet be small enough to pack into a match box.

Insulation: Case and insulation is of high dielectric phenolic. Careful attention in design has been given to British and overseas specifications for domestic appliances and compliance is assured by the provision of 5 mm minimum tracking paths throughout.

Actuation: Two types of built-in actuators are available, making the use of auxiliary hardwear unnecessary. In applications where the operating force can be applied in a straight line at right angles to the switch mounting, the cylindrical plunger of the "K5" switch is advocated. In other cases, when operation is by a revolving cam or by any device producing a sliding or sweeping action, the internally-pivotted, wedge-shaped actuator of the "K5C" switch should be used. Both types of actuator can be depressed in overtravel until they are flush with the switch case without reducing the long mechanical life of the switch.

Mounting: The switches may be mounted in any attitude by means of two 4BA (or similar) screws through 1 in. centre mounting holes provided in the side of the switch case. Alternatively, switches such as K5-HM and K5C-HM are provided with metal frames which offer horizontal lug-mounting facilities.



Three switches in the K5 range.

Switching facilities: The "K5" Series switches are of "double-break" construction and have two top and two bottom fixed contacts. In the "at rest" position the bottom fixed contacts are connected together and the top contacts are open. This arrangement provides single-pole change-over switching. For single-way, "off-on" switching, models with only the top contacts or only the bottom contacts are available.

Terminals: ¼ in. quick-connect ("Faston") tab terminals are provided, four on change-over switches and two on single-way switches. All terminals protrude through the switch base to facilitate a compact and tidy cable run.

REC 109 *for further details.*

RADIO & ELECTRONIC COMPONENTS

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Double-gun Helical p.d.a. Cathode-ray Tubes

The M-O Valve Co. Ltd's. range of double-gun helical p.d.a. cathode-ray tubes has been further extended by the addition of a 5 in. diameter tube, Type 1300F, for use in general-purpose oscilloscopes where two independent signals are displayed on a common time base.

The helical post-deflection acceleration has the advantage of giving increased brightness and sensitivity compared with non-p.d.a. tubes.

Deflection sensitivity in the x direction is 20 V/cm and in the y direction 12·5 V/cm with a gun voltage of 1·2 kV and a final anode potential of 4 kV. The line width is approximately 0·5 mm.

The minimum useful scan in the horizontal direction is 10 cm but in the vertical direction the common window is 7·5 cm. Side-pin connections to the deflector plates contribute to low input capacitance, and the overall length, excluding base pins, is 40·5 cm ± 0·5 cm.

REC 110 *for further details.*

Plastic Coating Powders

The Plastics Division of Dohm Ltd. has introduced a selection of plastic coating powders for the fluidized-bed/dipping process, in which the major proportion of the granules fall within that desirable particle-size range which gives excellent flow-out and fluidization characteristics—i.e. between 50 and 100 B.S. mesh. (Finer powders than this do not fluidize so uniformly.)

The powders, which include nylon and polyethylene, have been developed for a cold, dry powder process which is completely clean. Heated articles are passed through a tank containing the powder which is fluidized by means of compressed air being forced through a porous mattress in the bed of the tank. The powder, being aerated, behaves as liquid and adheres to every part of the metal article. On being withdrawn from the powder tank the article is lightly tapped to remove surplus powder, and reheated so that the plastic coating fuses smoothly. It is then air dried; or, if a glossy finish is required, quenched in a cold water tank.

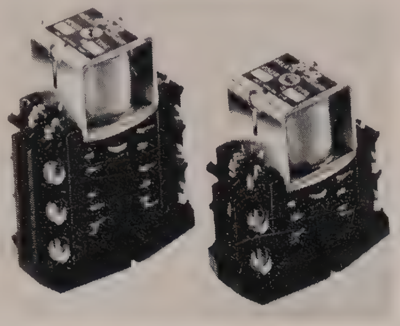
The process is said to be exceptionally clean. A dipping plant capable of performing the complete dip-coating cycle is available from the Company.

REC 111 *for further details.*

Industrial Contactor/Relay

B. & R. Relays Ltd. have recently added the first true contactor relay to their range. It is called the Q51 and is for a.c. operation. The Q51 combines two functions, it operates both as a heavy duty switch and as a normal relay. It is suitable for 440 V 50 c/s 3-phase industrial supply with an inductive 10 A rating.

There are two versions of the relay—the Q51/2 with two banks and the Q51/3 with three banks. The coil can be changed for other voltages and the relay may be tropicalized to DEF5000. Operating speeds on the two bank are 10—30 ms for pull-in and 10—25 ms for drop out. Pull-in for the three bank is also 10—30 ms, drop out 15—25 ms. AMP Faston connectors can be supplied, though the terminals, which are of the rising type captive clamp, are designed to hold two 7/0—029 cables.



Two bank and three bank versions of the Q51 contactor/relay.

The Q51 is designed to withstand a flash test of 2,000 V, and a wide variety of normally open or normally closed or change over contacts are possible. The two bank version weighs 11 oz.—the three bank 13 oz.

Applications for the Q51 are wide, and the relay has been under development for the last twelve months including prototype testing under actual working conditions. It may be used, for example, to control machine tool sequences or for switching a 3-phase motor direct on line.

REC 112 *for further details.*

High-power K-Band Reflex Klystron

Elliott-Litton Ltd., a member of the Elliott-Automation Group, has introduced a new K-band reflex klystron (Type 12RK4).

The new valve has been developed for use as a pump source for parametric amplifiers and masers and is capable of a minimum power output of 350 mW over a 500 Mc/s tuning range, centred in the band 21 to 25 kMc/s. An extremely rugged form of construction has been adopted, making the new klystron eminently suitable for airborne applications.

REC 113 *for further details.*

High-power Millimetre Wave Klystron

Elliott-Litton Ltd., a member of the Elliott-Automation Group, announces the introduction of a new high-power tunable klystron oscillator for the 4 mm band.

This klystron, the 4TFK3, has a tuning range of approximately 2,000 Mc/s. It can be supplied for operation within the band 68—80 kMc/s, and is capable of an average power output of 500 mW over the band.

Constructed as an harmonic generator-type klystron, based on the 10-W tunable Type 8TFK2 Q-band klystron, the 4TFK3 has an average life expectancy of at least 500 h. Output signals are exceptionally free from thermal drift and hysteresis, due to the water cooling of the resonant cavities and the use of the floating drift-tube principle for the Q-band bunching cavity.

REC 114 *for further details.*

Automatic Frequency Measuring System

Savings of up to £200 per operator are claimed to be effected in the production testing of crystal filters, oscillators, h.f. coils and chokes and other components where highly accurate frequency measurement and indication is essential. Racal Instruments Ltd., in order to reduce the expense involved in equipping each operator with frequency measuring test equipment, has devised a completely automatic frequency measuring system which is ideally suited to the production test environment.

Using only one frequency meter with an in-built translator control panel, the system enables accurate (±1 count ±1 part in 10^7) frequency measurements in the range 0—10 Mc/s to be made automatically by up to six operators, each operator having a separate in-line digital display unit. Under certain conditions, the frequency range can be extended to higher frequencies.

Comparisons of costs show that where the equipping of six operators with conventional equipment would cost close on £4,200, the Racal system for the same number of operators is in the region of £3,000, dependent upon the "tailoring" of the equipment to the customer's requirements.

The added advantages of the system are that full use is made of the test equipment, the operators are not "cluttered" with expensive apparatus, indication is made in easily-read in-line form, and additional readout units can be added at little extra cost.

The Racal installation comprises a Type SA.505 digital frequency meter, with its own built-in translator control panel, and the desired number of remote in-line readout panels, together with necessary control and automatic sequencing circuitry.

The automatic control panel provides a "queueing" mechanism so that the equipment can be used to its full capacity according to the type of installation and facilities required in the system.

Each remote position is fitted with a control panel enabling the operator to "call" the counter and make a frequency measurement. The measurement is displayed in illuminated numerals and each indication is held for five seconds. The terminal equipment is fitted in a standard 19 in. rack or can be bench mounted if desired.

A similar installation using a Racal SA. 21B digital counter has been installed for a 6-position production test bench for crystal filters at Marconi's Chelmsford Works. With a 3½ second display time, indication is given of frequencies based on a 100 kc/s fundamental. The in-line readout is fitted to Marconi's own scanning rack and the comparatively short display means, that with all operators using the system the maximum "queue" is only 17½ s.

REC 115 *for further details.*

Elapsed Time Indicator

Bergen Laboratories Inc. of the U.S.A. manufacture a small, simple device for indicating the time elapsed in electrical and electronic equipments. This is known as the Chronistor, and it is now available in the United Kingdom from Walmore Electronics Ltd.

In appearance the Chronistor resembles a cartridge fuse. It is a small electrolytic bath with the anode in the form of a rod. The passage of current causes the anode to be deplated and the change in length of the anode as shown on an engraved scale, indicates the time during which current has been flowing. Only a very small current is taken by the Chronistor.

This device provides a simple economical method for monitoring the operational life of electrical and electronic equipments. Also it is a convenient tool when it is desirable to replace certain components after a specified life, e.g. changing gramophone needles to save possible damage to valuable records.

Because of the low resistance of the Chronistor, a series resistor must be used with it.

Brief data: Physical size: Length 1¼ in., diameter ¼ in.

Standard time ranges: 100, 250, 500, 1,000, 2,500, 5,000, 10,000 h.

Resistance: 200 Ω.

Current: dependent on time range; varying from 34 μA for 10,000 h to 3·4 mA for 100 h.

Voltage: d.c. (or rectified a.c.).

REC 116 *for further details.*

Molytherm Grease

Molytherm grease has been designed by Rocol Ltd. specially to provide lubrication for industrial plant and machinery at a higher range of temperature than that of other high temperature greases. It is recommended for continuous service above 350°F., and withstands long periods above 450°F. and short periods up to 550°F. It is, therefore, able to lubricate many mechanisms previously lubricated only by silicones, and contains molybdenum disulphide to ensure its lubricating ability.

Based on a high flash-point oil and a non-soap thickener which is unaffected by heat or chemicals, Rocol Molytherm grease is soft enough to be applied through grease cups or nipples. It is resistant to steam and water, and shows considerable resistance to the stripping action of solvents and vapours.

Publication No. 17, which is available from Rocol Ltd., describes the grease and gives illustrations showing its superior heat stability to lithium and bentonite greases. The folder also gives a striking list of successful high temperature achievements in the metallurgical, chemical, engineering, glass and textile industries during the twelve-month development period the new product has undergone.

REC 117 *for further details.*

RCA Components

Details have recently been released concerning new components available from RCA Great Britain Ltd. These are as follows:

Epitaxial germanium transistor. This is designed for switching applications in critical military and industrial data-processing equipment. The transistor has been designated the Type 2N934 and is designed for high-speed applications. It utilizes a refined, precisely controlled technique for producing epitaxial layers on germanium wafers, which provides the designer of switching circuits with a transistor having high beta over a wide range of collector current, fast switching speeds, and low operating power dissipation. The low operating power dissipation of this transistor insures excellent stability by permitting operation at relatively low junction temperatures.

REC 118 *for further details.*

Germanium transistor. The Type 2N404-A is for medium-speed computer-switching applications. It is a germanium *p-n-p* alloy-junction transistor and has all the features of the popular 2N404 plus the following increased ratings for use in applications requiring such high ratings: collector-to-base voltage rating=40 V; collector-to-emitter voltage rating=35 V; emitter-to-base voltage rating=25 V; collector-current rating=150 mA; emitter-current rating=150 mA.

REC 119 *for further details.*

50 *W drift-field power transistors.* The 2N1905, 2N1906 are two new diffused-collector-graded-base power transistors of the germanium *p-n-p* type. These drift-field types utilize a combination of diffusion and alloying techniques to provide a built-in accelerating field in the base region. This field makes possible a wide frequency response and a linearity of characteristics over the entire operating collector-current range not available in conventional power transistors.

The 2N1905, 2N1906 transistors are particularly useful as high-power high-speed switches in d.c.-to-d.c. converters, and computers for data-processing equipment, as ultrasonic oscillators, and as large-signal wide-band linear amplifiers.

The 2N1906 differs from the 2N1905 in having a higher collector-to-base voltage rating, controlled switching characteristics, and controlled saturation voltage and beta at high current levels.

REC 120 *for further details.*

Full-wave vacuum rectifier. The Type 3DG4 is a full-wave vacuum rectifier tube of the glass-octal type intended for use in the power supplies of television receivers and in radio equipment having large direct-current requirements.

The 3DG4 in full-wave rectifier service with 550 plate-to-plate supply volts, can deliver to a capacitor-input filter 300 V at a d.c. output current of 350 mA.

REC 121 *for further details.*

Industrial germanium power resistors. Improved versions are now available of the popular 2N174 family of germanium power transistors for power-switching and amplifier service in industrial and military applications.

These transistors, which can now supply more useful power at no increase in cost, offer the equipment designer greater flexibility in circuit design and wider safety margins.

REC 122 *for further details.*

Miniature pentode. The 6GX6 is a new sharp-cutoff pentode of the 7-pin miniature type having two independent control grids. The 6GX6, formerly known by its developmental No. A40309, has been designed by RCA electron tube engineers particularly for use as a combined detector, limiter, and audio voltage-amplifier and driver tube in locked-oscillator, quadrature-grid f.m. sound-detector service.

REC 123 *for further details.*

Microswitches

General Controls Ltd. is now manufacturing in the United Kingdom a very complete range of Klickswitches (microswitches) and by combining a multitude of actuator sub-assemblies, with basic klickswitches. General Controls is able to offer a range of switches that will cover most industrial and domestic applications.

The Klickswitch is a precision made, dependable snap action switch, built into a moulded phenolic case. This moulded plastic enclosure provides excellent resistance to vibration, corrosion, and temperature change. Klickswitches assure extreme repeat accuracy, heavy and light current switching capacity, and contact reliability.

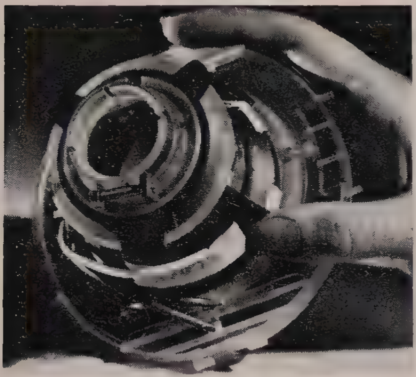
General Controls also offers a range of sealed-enclosure type Klickswitches, which exclude dust and moisture. These, again, have a multitude of different type actuators and actuator sub-assemblies, that will cover most switching problems.

Catalogues are available showing the range of Klickswitches together with a range of temperature, level and pressure control equipment, including control valves both electrically and pneumatically operated, ranging up to 16 in. trim size, and all types of associated components.

REC 124 *for further details.*

Polypropylene Linear Scan Coils

"Carlona P" polypropylene, manufactured by the Shell Chemical Company Ltd., is now being used by Kent Mouldings Ltd. to mould a television deflector coil for 110° television tubes for the Plessey Co. Ltd. This new application illustrates the electrical resistance, lightness and strength of "Carlona P".



Deflector coil using "Carlona P" polypropylene.

The rigidity of the material is maintained at the elevated temperatures encountered in television receivers in the United Kingdom and overseas. This material has also proved suitable for use in television sets housed in the new, smaller cabinets.

REC 125 *for further details.*

New Silicone Resin

Cement-bonded asbestos board is widely used as a non-inflammable, non-tracking and heat resistant electrical insulating material. In many applications, however, its high rate of water absorption with consequent loss of insulating properties is a serious limitation. This disability can be overcome by impregnation of the board with a suitable silicone resin.

Midland Silicones Ltd. has recently developed a new resin especially for impregnating asbestos board. This is DP 2728, supplied as a low-viscosity solution in toluene.

Asbestos cement board impregnated with DP 2728 is said to retain good electrical insulating properties for very long periods even in conditions of 100% relative humidity, whereas under similar conditions untreated board will soon show a serious loss of insulation resistance.

Silicone-impregnated asbestos board is widely used for arc chutes in air-break switchgear or as spacing insulation on electrical apparatus where Class C (over 180°C—BS.2757 and IEC Publication No. 85) performance is required. It is particularly useful in the construction of dry-type transformers, in domestic appliances and as a substitute for paper-phenolic boards where heat or flame resistance is needed.

REC 126 *for further details.*

Germanium

Johnson Matthey & Co. Ltd. announce that zone-refined (50 Ω-cm, *n*-type) germanium is now available, normally in ingots having a nominal weight of 1 kg. A large scrap-recovery plant has been installed which enables a wide variety of types of germanium-bearing residue to be processed. The Company now wishes to purchase large or small quantities of germanium scrap, and will be pleased to hear from any organization having such material for disposal.

REC 127 *for further details.*

Miniature D.C. Relay

B. & R. Relays Ltd., a member of the Gas Purification Group, have announced a new relay which is the smallest in their range.

Styled the B.14, this inexpensive relay measures $1 \times \frac{15}{16} \times 1\frac{3}{32}$ in. and weighs only 1 oz.

The B.14 has a maximum of one change-over silver or silver-cadmium oxide contact, and the common contact is connected to the relay frame. The contact gap is 0·015 in. and the contact pressure is 8 grammes minimum. Nominal operating power is 100 mW although the relay will operate at 80% of this figure.

Miniature d.c. relay.

The operating time at maximum power is 3 ms.

REC 128 *for further details.*

Magnetron for Marine Radar

The English Electric Valve Co. Ltd., announces that its 80 kW fixed frequency non-packaged magnetron, the M561, is now in quantity production after exhaustive proving tests. Operating in the marine S-Band, 3040 to 3060 Mc/s, the magnetron will be notable for reliability and very long operating life. The coaxial output circuit will withstand instantaneous overloads of up to 1 MW, and the proving programme, conducted at sea and in the laboratory, has shown that this very conservatively rated and mechanically robust magnetron will be a valuable addition to the English Electric range of special tubes.

Summary of characteristics

Electrical:	
Cathode:	Indirectly heated oxide coated
Heater voltage:	10 V
Heater current:	1·1 A
Mechanical:	
Overall dimensions:	6·28 × 6·11 × 3·28 in.
Nett weight:	3¼ pounds
Typical operation:	
Heater voltage:	7·5 V
Magnetic field:	1,800 Gauss
Anode current (peak):	15 A
Pulse length:	1·0 μs
Pulse repetition rate:	1,000 p.p.s
Anode voltage (peak):	13 kV
Output power (peak).	80 kW
Output power (mean):	80 W
Frequency pulling:	5 Mc/s

A version of the M561 with alternative heater ratings is also available. These ratings are: *Electrical:* 6·3 V 1·5 A; *Typical operation:* 4·7 V.

REC 129 *for further details.*

Image Orthicons

The General Electric Company of America has doubled its line of image orthicons with the addition of four new highly-sensitive camera tubes with a wide range of applications. The new tubes are available from International General Electric Company.

The most sensitive of the new image orthicons is designated GL-7967. It uses a tri-alkali photo-cathode in conjunction with a magnesium-oxide semiconductor target to provide 50 times more sensitivity than standard image orthicons.

General Electric engineers say that the GL-7967 can operate with photo-cathode illumination of 10^{-6} foot-candles or less. The magnesium-oxide semiconductive target used in the GL-7967 has almost no lateral leakage, and when this storage capability is used illumination of below 10^{-7} is sufficient for clarity.

At these extremely low light levels, the GL-7967 is capable of resolutions in excess of 300 television lines. At higher light levels, it can achieve resolutions in excess of 1,200 lines. Typical applications for the tube include extreme low light level surveillance, orthicon intensifier uses and underwater observation.

The other three new image orthicons are the GL-7969, Z-5395 and GL-7409.

The GL-7969, supersensitive in the ultra-violet region, is expected to be used in medical laboratories for blood and cell studies in the biochemical field. Its low light level capabilities of down to 10^{-5} foot-candles will allow pictures of tissue to be taken and enlarged for medical examination. Light levels formerly required for this work sometimes caused damage to the material under study.

The ultra-violet spectral response of the GL-7969 also makes it an important addition to missile detection systems and to spectrographic detection. The tube has highly technical applications in defence systems previously thought impossible because of the lack of sensitivity in available tubes. In X-ray use, the GL-7969's extreme sensitivity will reduce the number of exposures necessary for diagnosis or treatment, thereby substantially lowering X-ray dosage to the patient and operator. Because of its high resolution, it permits greater detail to be observed than previously possible.

Another of the new tubes, the Z-5395 with near infra-red spectral response, has broad application in the commercial and defence fields. The tube can be used to penetrate hazy atmospheres for mapping and surveillance operations, as well as in passive detection systems.

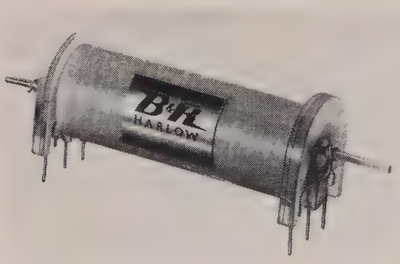
The fourth new image orthicon, the GL-7409, features rugged construction and high sensitivity for military applications.

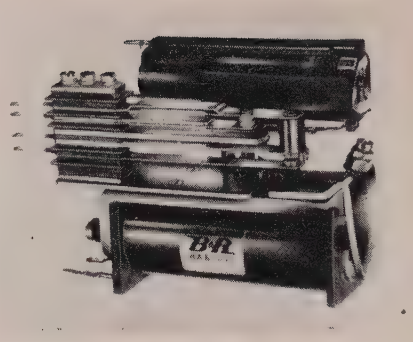
REC 130 *for further details.*

New Relays

Mounted on a nylon bobbin and measuring only 1 in. in diameter by 2 in. long, less reed ends, B. & R. Relay's latest dry reed relay Type R.03 weighs approximately 2 oz. It has been designed for printed-circuit application and is fitted with six standard contact prongs. The relay contains one normally open reed. Coils may be specified to requirements with resistances up to 20 kΩ, and while a nominal power of 0·06 W is required the relay will operate efficiently at 0·048 W. As with previous dry reed relays in the B. & R. range the R.03 is d.c. operated and has a similarly high life expectancy—(20×10^6 operations at maximum contact rating) and a contact resistance of 0·030 Ω.

Type R.03 relay.





Type B.04 relay.

The switching of relatively high and inductive loads by a small input source is a feature of the Type B.04 relay, which may be fitted with 1 normally open or normally closed vacuum switch together with up to 3 make, break or changeover type B.O. contacts. The relays are $4\frac{1}{2}$ in. long and depending upon the contact arrangement up to $3\frac{1}{4}$ in. high. The operating position is universal and the weight is approximately 10 oz.

REC 131 *for further details.*

"Press-Fit" Feedthrough Terminal

SWC connections may now be made utilizing Sealectro "Press-Fit" p.t.f.e. terminals. The new development is announced by the Sealectro Corporation, and is made available through the introduction of the new "Press-Fit" Part No. FT.WJ.100 feedthrough terminal.

The terminal is rectangular in shape, with truncated circular ends. The chassis is prepared with a punch, forming a rectangular shape with bevelled entrance. The terminal, when pressed in and properly seated, provides extremely high torque resistance.

The stud is rectangular with prescribed cross-section configuration for optimum contact and mechanical holding power on the wire. The unit is 1·2 in. overall in height, with a lug above the chassis of 0·460 in., and below 0·459 in. The cross-section of the lug is 0·045 × 0·036 in. Chassis mounting hole calls for inside measurement of 0·112 × 0·175 in. diameter.

REC 132 *for further details.*

"Press-fit" Test Jacks

Employing long-life beryllium copper contacts, "Press-fit" p.t.f.e. test jacks are claimed to have an extended life in excess of 100,000 insertions and withdrawals with no appreciable increase in contact resistance. Accelerated life tests currently being conducted show that these components meet or exceed all normal applications requirements.

The Sealectro Corporation offers a complete range of p.t.f.e. test jacks featuring the "Press-fit" design which permits instantaneous installation in a punched, or drilled chassis. The body is available in all standard coding colours for identification of test points. Jacks are available to fit standard 0·040, 0·050, 0·060 and 0·080 in. probes. Circuitry connection from the test jack may be stamped lug, single or double turret, PW, or other configuration to meet specific requirements. The terminal lug is plated gold flash over silver.

REC 133 *for further details.*

Automatic Wire Stripper

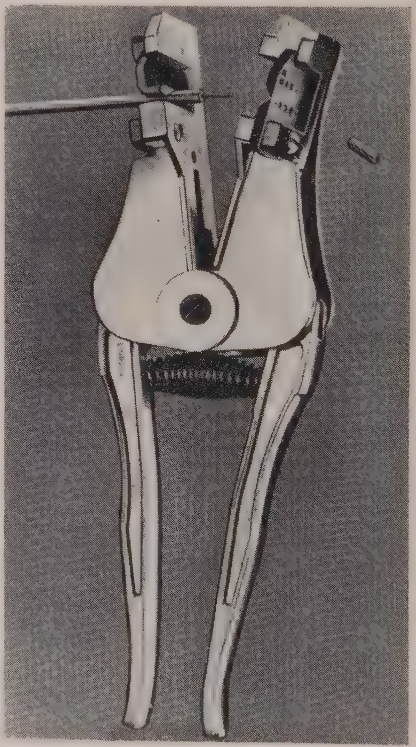
Hellerman Ltd. has added two new series of wire strippers to its already extensive range.

Standard model. The standard model is ideal for normal commercial use and will strip wire clean up to $\frac{7}{8}$ in. long. An automatic device holds the jaws open without crushing, and practically all nicking, cutting or fraying is eliminated. This new tool is especially suitable for production stripping of lighter gauge wires, automatic wiring, radio and instrument wires and cables and telephone wiring. The blades of the new wire stripper are easily changed and the complete tool weighs only 14 oz.

De-luxe model. The de-luxe model has been designed for use on aircraft and guided weapon cables and similar high quality precision work. The unique blade construction and extreme holding power of the broad jaws permit fast, accurate stripping.

This tool has been designed to strip with-

Automatic wire stripper

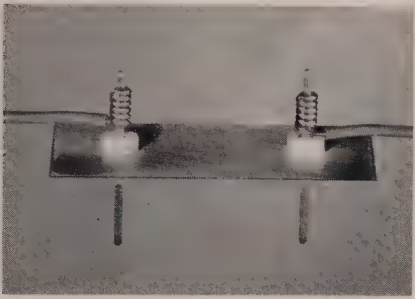


out nicking or scraping wire and without marking insulation. Like the standard model, the de-luxe version weighs only 14 oz.

REC 134 *for further details.*

Miniature Feedthrough Terminal Pigtail Lead

A soldering operation is said to be completely eliminated through the use of the Sealectro press-fit Type FT-M-9 miniature feedthrough terminal with pigtail lead. The unit has a standard pin lug on the opposite end from the pigtail lead. This pigtail lead is 1½ in. long, but may be specified in other lengths upon special order. The lead allows bending to other terminations for point-to-point wiring. It is especially adaptable to printed wiring boards and is used in computer assemblies.



Sealectro "Press-fit p.t.f.e. feedthrough pigtail extension terminals.

REC 135 *for further details.*

Gallium Arsenide

Johnson Matthey & Co. Ltd. are now able to offer sample quantities of this intermetallic compound in polycrystalline form. It is also hoped that single-crystal material will be available shortly.

Typical properties of polycrystalline gallium arsenide are given below:

Resistivity ...	... 0·01—0·2 Ω-cm
Hall coefficient	... 50—250 cm³/C
Electron mobility	2,000—4,000 cm²/V s
Carrier concentration	1—30 × 10^{16}/cm³

The material is available either as broken ingot or cut slices.

REC 136 *for further details.*

Long-scale, Meter-type Relay

MagTrak, (TM) a relay concept said to ensure positive make of relay contacts—even when contact voltage is low and contacts have become contaminated with surface film—has just been introduced by the Weston Instruments Division of Daystrom Ltd.

Experience with existing load-current-contact-aiding (l.c.c.a.) relays has shown that, under high-sensitivity and high-accuracy applications at low switching voltages, reliable contact closure was not always obtainable due to contact contamination.

Weston engineers, aiming for an increase in relay reliability by greatly increasing initial contact pressure, developed the MagTrak principle. This principle will be applied to all standard Weston l.c.c.a. relays.

The MagTrak contact pressure aiding feature consists of the addition of a soft iron bead on the moving pointer and addition of a permanent bar magnet assembly on each adjustable index arm. When the pointer reaches the control point, the bar magnet pulls in the pointer and moving contact against the flexible index arm contact with a rapid snap-wipe action. The force—in the order of 20 to 40 mg—is sufficient to overcome contact films, even at low contact voltages.

In addition to the increased pressure that MagTrak provides to physically break existing high-resistance films that form on the contacts, the quick, positive contact reduces transient arcing and so increases contact life and prevents the contacts from welding.

Weston has made first use of the new principle in the Model 1073 MagTrak relay. As in standard l.c.c.a. relays, the Model 1073 carries one relay contact on the pointer of the instrument and the mating contact on a flexible platinum-iridium strip attached to an adjustable index arm. The moving coil of the metal relay has an additional winding isolated from the sensing winding which is placed in series with the load when the contacts are closed. Current passing through the load also passes through the additional winding and produces a pressure of about 1 to 3 g magnitude. This pressure assures a firm, positive make and causes compression of the flexible platinum-iridium contact on the index arm.

Without the MagTrak feature, the initial contact is dependent on the pressure provided by the instrument torque and the electrostatic attraction due to the potential difference between the contacts. If the initial pressure is sufficient to break built-up films, as assured by MagTrak, the usual l.c.c.a. operating sequence occurs. Some current will flow through the load and the locking winding on the moving coil, increasing the contact pressure and permitting more current to flow until the current reaches the steady state and final contact pressure reaches about 1 to 3 g.

In the Model 1073 MagTrak relay, as in common l.c.c.a. types, contacts once made must be reset by an interrupting technique. A push-button switch, mounted on the front of the case, is used to break the current through the meter locking winding. When this current is broken, the force against the compressed flexible contact is relaxed and the stored potential energy of the spring becomes kinetic energy and kicks away the moving contact, with sufficient force to override the permanent magnet.

Weston engineers estimate the MagTrak feature provides a ten-fold increase in relay reliability, assuring function of an instrument even after months have passed without the need for the contacts to close, and possible contact contamination has occurred.

Relays equipped with MagTrak are also capable of handling lower voltage loads without redesign of the instrument circuit. While the normal l.c.c.a. instrument range is 75-125 V, Weston has employed voltages as low as 6 V in MagTrak instruments. It is anticipated that voltages as low as 4 V may be attained.

REC 137 *for further details.*

Light-duty Electro-magnetic Counter with Manual Preset

This light-weight counter, Type 1250, has been designed by Counting Instruments Ltd. primarily for hot and cold drink dispensing vending machines, though many other applications exist.

It is a three-figure model with manual preset which enables the counter to be set to a predetermined number and when pulsed subtracts to zero when a micro switch either opens or closes a circuit.

The cutout device is so arranged that the unit can be preset at any number between zero and 999.

Models are available for most standard voltages from 24 V d.c. to 230 V a.c. and care in the design has been taken to ensure that the unit is unaffected by humid conditions.

Electro-magnetic counter.

REC 138 *for further details.*

New G.E.C. Connectors

Quicker and simpler assembly of electrical connectors in equipment such as computers, telephone distribution boards, instrumentation units, are said to be the advantages of a new connector assembly introduced by General Electric Co. Ltd.'s Installation Equipment Group. The new product can be incorporated in circuits up to 660 V.

The connector assembly consists of a plated brass terminal unit and a specially-shaped porcelain block; a large number of

Continued on page 616

MANUFACTURERS' PUBLICATIONS

Magnetrons

The English Electric Valve Co. Ltd. has issued a folder giving brief details of the comprehensive range of Magnetrons designed and manufactured by the Company. The types are listed in order of code numbers together with service type numbers and ascending nominal frequencies.

REC 143 *for further details.*

Silicones for the Electronic Industry

The widespread uses of silicones in electronic equipment are summarized in a well-produced 24-page illustrated booklet published by Midland Silicones Ltd. The booklet describes the main types of silicone products of use to the electronic industry and quotes from actual examples of successful applications of the Company's products by many firms in the electronics field.

The booklet is divided into three main sections: the first dealing with the encapsulating, impregnating, filling and coating of materials; the second with fabricated insulating and structural components; and the third with production aids.

REC 144 *for further details.*

Transformers

Two leaflets, recently published by The Belclere Co. Ltd., describe four types of transformer which the Company has recently introduced. The first leaflet concerns the Type XN miniature assembly which is thought to be the smallest transformer in the world. Its dimensions are $0{\cdot}25\times0{\cdot}30\times0{\cdot}25$ in. and it consists of minute super-mumetal laminations, a moulded bobbin, and a simple space saving fixing clamp, which is suitable for use on a printed-circuit board or on a small metal chassis. The second leaflet describes three sub-miniature driver transformers for Mullard 100 and 200 mW transformerless output amplifiers. Type EN. 2592 is for 200 mW output; Type EN.2593 is for 100 mW output; and Type BN.2594 is for 100 mW output. The dimensions of the first two are $1\times\frac{3}{4}\times\frac{3}{4}$ in. high and the dimensions of the latter are $\frac{3}{4}\times\frac{5}{8}\times\frac{9}{16}$ in. high.

REC 145 *for further details.*

Londex Ltd.

To celebrate their Silver Jubilee, Londex Ltd. has produced a 52-page data book. The Company has extended their range of products from the initial manufacture of relays (of which they have something in the region of 2,000,000) to complete automation plants including controls of level, flow and pressure.

Details are also given of the Company's relays, timers, photo-electric equipment and counters, fluid and gas controls. The publication includes an index.

REC 146 *for further details.*

Electrical Accessories

Several new lines have been added to the 1961 colour catalogue published by MK Electric Ltd.; these include a luminous locator, a unique facility for finding switches in darkness, flex outlet plates (fused and unfused), and steel boxes for use with MICC cable.

The back page is devoted to standard conditions of sale.

REC 147 *for further details.*

Industrial Plastic Materials

The Nylonic Engineering Co. Ltd. has issued a 44-page catalogue giving technical details and specifications of the plastic materials which it manufactures for industrial, rather than for commercial, use. Nylon, Polyacetal, Polycarbonate and Polypropylene are manufactured in the form of rod, sheet, tube, mouldings, gears, machined parts and extruded sections.

REC 148 *for further details.*

Valve Replacement Index

The index, issued by the English Electric Valve Co. Ltd., lists valves of various manufacturers for which E.E.V. valves may be used as replacements. Service type numbers are also listed. In most cases replacement is a simple plug-in matter but where some minor adjustment to the circuit may be necessary this is indicated by an asterisk.

REC 149 *for further details.*

Computer World

The March-April issue of this Ferranti bi-monthly publication for executives and engineers contains the following main articles:

Computers in Banking; The Argus Computer System for Boiler Control; Air Traffic System; New Ferranti Computer Film; and an article on the Sirius computer.

REC 150 *for further details.*

Magnetic Stereo-cartridge

Tannoy Products Ltd. has produced a leaflet concerning the Vari-twin Mk. II magnetic stereo-cartridge. This is a magnetically balanced four-pole system employing 45/45 sensing elements, having the advantage that playing weight has a negligible effect on cross-talk. The compliance of the stylus assembly, together with its associated damping, may be easily changed without returning the unit to the manufacturer. The specification is as follows:

Frequency response ...	30 c/s—15,000 c/s $\pm1{\cdot}5$ dB.
Output	7 mV per channel.
Inductance	350 mH.
Maximum termination capacity	150 pF.
Stylus material ...	Diamond.
Stylus dimensions ...	0·0005 stereo only. 0·0007 compatible.
Tracking pressure ...	4 gm.

REC 151 *for further details.*

Stereo Ceramic Cartridge

An illustrated folder, published by Collel Ltd., is concerned with their SCl stereo ceramic cartridge which uses lead zirconate elements suitable for all climatic conditions. The approximate sensitivity when connected to 1 MΩ, 100 pF capacity cable is 120 mV/cm/s eff (nom). Sensitivity difference between the two channels is <3 dB; lateral compliance (micro tip) $= 5{\cdot}0\times10^{-6}$ cm/dyne; separation at 1,000 c/s = 20 dB (min); recommended stylus pressure = 3 to 6 gm; frequency range = 20 to 20,000 c/s; recommended terminal resistance = 1 MΩ.

REC 152 *for further details.*

D.T.V.—Service to the Electronics Industry

Direct TV Replacements Ltd. has produced a useful Industrial Handbook which lists the many electronic components and various items of test equipment which the Company is able to supply to the electronics industry. A same-day service is available on orders received for many of the products available and these include the following:

Chemical; capacitors; resistors; thermistors, diodes and metrosils; controls; plugs, sockets and terminal blocks; valveholders; specialized windings; e.h.t. supplies; valves; tools; instruments and equipment; lighting controllers; photoelectronic switches, and intercommunications equipment.

REC 153 *for further details.*

Kabi Stock Control Aids

A leaflet has been published by Kabi (Electrical & Plastics) Ltd. which lists the range of self-adhesive stockmarkers, label holders, letters and numerals, and industrial tapes.

REC 154 *for further details.*

Superheterodyne Receiver

Standard Telephones & Cables Ltd. has issued a 12-page booklet MK/162, Ed. 1, describing a transistor superheterodyne radio receiver circuit. This offers medium and long wave coverage employing semiconductor devices. A 500 mW maximum output guarantees a favourable performance under adverse conditions. There are a number of graphs together with an appendix.

REC 155 *for further details.*

Products and Activities of the 600 Group of Companies

The George Cohen 600 Group Ltd., the Holding Company of "The 600 Group of Companies", derives its name from the fact that in the year 1876 George Cohen transferred the headquarters of the firm, which was established in 1834, to 600 Commercial Road, London—premises where the Group still occupies a large wharf, warehouses and offices. Subsequently, people spoke about "going to 600". The Group, which involves 36 companies, is mainly concerned with raw materials for the iron, steel and non-ferrous metals industries, a very wide range of plant and machinery for many applications together with other associated activities. An eight-page folder gives a reasonably comprehensive outline of the activities of the Group together with the names and addresses of the associated companies.

REC 156 *for further details.*

Electronic Timers

List No. 190 P 3/61 from Londex Ltd. gives details of an addition to the Company's existing range of timing devices. This new item is an electronic timer Type TY and is available in five time ranges from 0·25 to 120 s. Full information, together with illustrations, is included and delivery is quoted at eight weeks.

REC 157 *for further details.*

Co-operative Electrical Research

This publication is the House Journal of The Electrical Research Association. The particular issue under notice is that for April. It contains three technical articles as follows:

"*Note on the History and Use of the E.R.A. Side-blast Arc Control Unit for Large Electric Circuit-breakers.*" By W. B. Whitney.

"*Sphere-gap Standards for High Voltage Measurement.*" By A. Morris Thomas.

"*Brief History of E.R.A. Research on h.v. d.c. Transmission.*" By A. P. Paton.

Other items, which are mainly of interest to members of the Association are a report on the visit to India in November, 1960 by Mr. W. H. Devenish; news of the various Divisions of the E.R.A.; contracts for research and testing; Association news; E.R.A. reports and news of other E.R.A. published material.

The Journal is available at the price 2*s*. 6*d*. plus 6*d*. postage.

REC 158 *for further details.*

Printed Circuits

The design and production of printed circuits is the subject of a brochure from Technograph Electronic Products Ltd. This brochure has been designed to act as a guide to all engaged in the manufacture of equipment using printed circuits.

Electro-plating specifications are given together with application data. There is a chart of standard printed-circuit tolerances, together with a number of leaflets dealing specifically with one type of printed circuit or process contained in an envelope at the back of the brochure.

REC 159 *for further details.*

Export

Export is the latest publication to be issued by E.M.I. Electronics Ltd., and is designed to describe the Company's efforts to increase export sales, and acquaints the reader with the latest electronic developments. Every article is printed in four languages side by side—English, French, German and Spanish, and the publication is well illustrated.

REC 160 *for further details.*

"Prestincert"—A new fixing technique

The Third Edition of a 12-page booklet, published by Belling & Lee Ltd., gives details concerning the "Prestincert" technique. This is a unique principle of mounting components of all kinds on panels or chassis of any material, on die castings, etc., and of riveting laminae together without the necessity of resorting to preparatory punching or drilling operations. The technique was developed as a means of mechanical fixing, and there are many applications for it in the engineering industry where it offers an alternative method to conventional riveting. There are applications, too, where the technique is said to offer advantages over seam and spot welding, enabling unskilled labour to produce joints which are mechanically as strong, or even stronger, with virtual elimination of failures and weak joints which are difficult to detect until they fail.

REC 161 *for further details.*

Annual Review of The Solartron Electronic Group

The title which has been given to this publication is "New things under the sun". The *Review* is extremely well produced with many photographs in full colour showing Solarton installations in use at various well-known scientific and industrial establishments. A chart indicates the steady growth of deliveries to customers during the period 1954-1961 with an illustration of the rapid expansion of the Group's export market. The text, by Mr. Stubbs Walker, objectively reports the many Solartron achievements in the scientific field.

REC 162 *for further details.*

Variable Condensers and Drives

Jackson Bros. (London) Ltd. has issued an illustrated folder giving data for its very wide range of radio condensers, drives and associated components.

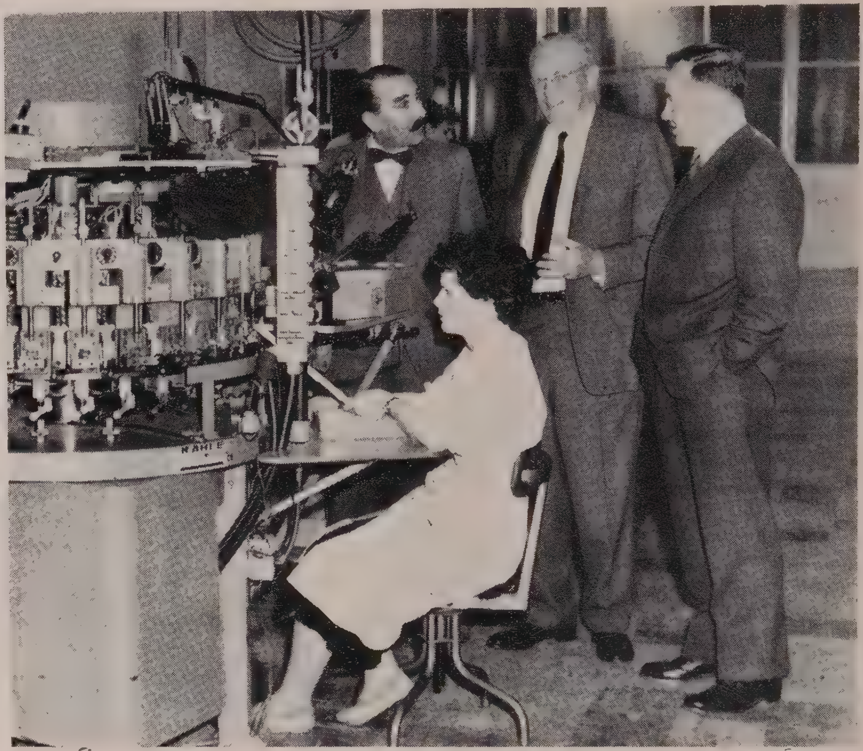
REC 163 *for further details.*

Murphy News

The May issue of *Murphy News* from Murphy Radio Ltd., contains details of the new Astra range, and in particular mention is made of the Model V689, the de-luxe television with v.h.f. radio. This table television has a 19 in. 114° cathode ray tube and is suitable for use in fringe or strong signal areas with black-level a.g.c. in the vision receiver and automatic contrast control.

REC 164 *for further details.*

ACTIVITIES *in the Industry*



Mr. L. A. Hyland, Vice President and General Manager of Hughes Aircraft Company, recently visited the plant of Hughes International (U.K.) Ltd. at Glenrothes, Fife, Scotland. In this photograph he is seen (centre) with Mr. David Simpson, General Manager of Hughes International (U.K.) Ltd. (right of picture) and Brigadier A. R. Purches, General Manager of Glenrothes Development Corporation. They are watching an operator at one of the fully automatic machines—the first of their kind in the United Kingdom—each producing 2,500 hermetically-sealed germanium gold-bonded diodes per hour.

Mobile Showroom for The Solartron Electronic Group Ltd

In furtherance of The Solartron Electronic Group's intensive drive on world markets they have just commissioned a specially built mobile demonstration showroom for use in Europe.

The vehicle, which is said to be the largest non-articulated showroom of its kind in the United Kingdom is fully equipped to demonstrate electronic equipment and includes its own power generator; it also provides living quarters for its crew of three, and includes kitchen with refrigerator, clothes drier and cooking facilities.

The mobile demonstrator was despatched to Poland to supplement the Solartron exhibit at the Poznan Fair. It then visited the I.M.I.S. Exhibition at Budapest, Hungary.

The Solartron mobile showroom carries a very comprehensive range of Solartron equipment, such as a digital data recorder, a 100-channel digital data recorder system with alarm facilities and typewriter output, a complete range of precision electronic instruments, a range of oscilloscopes, including the well known CD.1014 portable double-beam oscilloscope, the new pulse generator GO.1005, dynamic analysis and servo test equipment, the LP.942 fast analogue to digital converter and associated translator unit, digital voltmeters, the NT.4-980 vibrating cylinder-type transducer, and the general-purpose analogue computers SC.30 and SC.10; the former, together with its peripheral equipment is in operational order. The value of the equipment carried is of the order of £30,000.

E.M.I. Computer at Barclay's

E.M.I. Electronics Ltd. has delivered and installed the EMIDEC 11 computer at Barclay's Bank No. 1 Computer Centre in Drummond Street, Euston. It will be used to undertake the centralized book-keeping of 40,000 current accounts for 12 of the Bank's West End branches.

The proposed system of operation, using information transmitted by teleprinter is thought to be the first of its kind in any bank in the world. This bank book-keeping system lessens staffing difficulties and the overcrowding of premises caused by the ever increasing volume of work. Redundancy will not occur as a result of this installation in view of the existing pressure on the Bank's staff.

The computer was ordered in August, 1959 after intensive investigations into various communications techniques had been made and it was decided that this "1100" was the most suitable for Barclay's Bank. It is an all-transistor machine employing the most advanced techniques and is still the only transister computer working today with magnetic tapes on a customer's premises in Great Britain. The use of magnetic cores and transistors throughout ensure a very high degree of reliability.

The main unit of the computer comprises a magnetic-core store giving immediate access to 1,024 words, a 16,384 word magnetic drum, a parallel arithmetic unit, and a control unit in which the detailed machine operations are controlled from the lacing of a matrix of magnetic cores. In conjunction with the main computer are magnetic tape units on which the main record for all accounts is stored. Photoelectric paper-tape readers, and high speed paper-tape punches, both operating at 300 characters a second, provide input and output to the computer.

British Railways' Multi-channel Radio Telephone System

As part of the British Railways modernization programme, its north-eastern region is to be equipped with a super-high-frequency multi-channel radio telephone system between York and Newcastle *via* Darlington—a distance of 78 miles. This will be the first multi-channel radio telephone and telegraph installation to be used by British Railways and, indeed, the first "private" multi-channel service in Britain to operate on a frequency of 7,500 Mc/s.

The radio equipment is to be supplied and installed by Marconi's Wireless Telegraph Co. Ltd., and the carrier equipment by Automatic Telephone and Electric Co. Ltd.

The system is designed for a maximum capacity of 300 telephone channels, but initially 180 will be in operation. It will handle the telephone traffic between the regional centres, with full facilities for through subscriber trunk dialling; ultimately its use may be extended to provide facilities for high-speed data transmission—for example, it could be used as a means of centralizing account systems.

The installation is duplicated to operate on a main/standby basis, with automatic changeover in the event of failure. In this connection, particular features of the equipment are the relatively low number of valves used and the simplicity of the r.f. transmission circuits, which employ one microwave klystron per unit equipment, both factors which greatly reduce the probability of equipment failure. The telephone channelling equipment is of the latest design, using transistors throughout and printed-wiring cards for mounting all components.

Two repeater stations will be used; one at Woolmoor between York and Darlington and the other at Ferryhill between Darlington and Newcastle. Three channels will be dropped in each direction at each of the repeaters.

A survey of the route to establish final tower heights and system performance is currently being carried out by Marconi engineers and the contract is scheduled for completion in 15 months.

Walmore Electronics Ltd. and Motorola Semiconductor

Walmore Electronics Ltd. has been appointed the United Kingdom distributor for the products of Motorola Semiconductor Products Inc.

Motorola Semiconductor Products Inc. is one of the best known manufacturers of semiconductor devices in the U.S.A. and included in its products are the following:

Epitaxial transistors. A range of silicon and germanium types amplifiers and switches with cut-off frequencies of 400 to 500 Mc/s are now available.

Power v.h.f. mesa transistors. Dissipation of 3 W, output of 0·5 W at 160 Mc/s.

Power transistors for industrial applications. Dissipation up to 120 W, currents up to 25A.

Power Zeners up to 50 W, 200 V.

McMurdo Instrument Co. Ltd.

The McMurdo Instrument Co. Ltd. announce that, as an aid to quicker delivery of small orders for Ministry released valveholders, they have made arrangements with the Stewart Aeronautical Supply Co. Ltd. to act as stockists for the most commonly used types. The prices will be identical with those obtained directly from McMurdo and customers will find it beneficial to place orders for 500 or less Type Approved valveholders directly with Stewart Aeronautical Supply Co. Ltd., Adastral House, Nutfield, Redhill, Surrey (telephone Redhill 5050).

Murphy Radio Ltd.

Murphy Radio Ltd. has announced that, with effect from the 4th April, 1961, all the administration and manufacture of v.h.f. radio telephone units was transferred to new premises at the following address: 23 Stonefield Way, Victoria Road, South Ruislip, Middlesex, Tel.: VIKing 5651.

All correspondence, verbal enquiries, etc., should be addressed accordingly.

This move has been made so that maximum effort can be concentrated on production, together with an improved aftersales service.

The Ferrograph Co. Ltd.—Change of Address

The London offices, showrooms and service department of The Ferrograph Co. Ltd. (incorporating also the British Ferrograph Recorder Co. Ltd., Rendar Instruments Ltd. and Wright & Weaire Ltd.) will be moved from 88 Horseferry Rd., S.W.1, where they have been temporarily located, to their permanent address at 84 Blackfriars Road, S.E.1, telephone WATerloo 1961.

U.S.A. Distributor for E.E.V.

The English Electric Valve Co. Ltd. has appointed Calvert Electronics Incorporated, 536 Broadway, New York 12, N.Y., U.S.A., as Distributor throughout the U.S.A., for all the Company's products other than television camera tubes.

New Offices for Mullard Valve Division

The Government and Industrial Valve Division of Mullard Ltd. is now in new offices at 80 New Oxford Street, W.C.1. The telephone number is LANgham 5522.

Visitors to the Government and Industrial Valve Division should go to 80 New Oxford Street, but correspondence should continue to be addressed to Mullard House.

Mullard Films go into Archives

The National Film Archive, a department of the British Film Institute which preserves in the national interest films of historic and artistic value, has selected the following five Mullard films for preservation:

Conquest of the Atom (made in conjunction with the Educational Foundation for Visual Aids); **Manufacture of Junction Transistors; Mirror in the Sky** (made in conjunction with the Educational Foundation for Visual Aids); **Ultrasonics; The Manufacture of Radio Valves.**

"Mirror in the Sky" and "Conquest of the Atom" have both gained premier awards at the Harrogate Festival of Films in the Service of Industry, and the latter also won a gold award for Educational Films at the first International Festival of Films for Television.

Aveley Electric Appointed Agents for American Company

Aveley Electric Ltd. has been appointed sole United Kingdom agents for the Hudson Tool & Die Co. Inc. of Newark, New Jersey, U.S.A.

The Hudson Company manufactures drawn and pressed metal enclosures for electronic components. Over 1600 different standard cans are available on stock or short delivery. This variety of sizes, including MIL-T-27 types, is available in eight different metals comprising nickel-silver crystal cans; multiple nesting-type shields in copper-mumetal and steel, round, square and rectangular types with covers for hermetic sealing, and in some types with integral mounting flanges.

Aveley Electric Ltd. is using a variety of this range as standard enclosure for their toroids.

Part of the range of drawn and pressed metal enclosures.

Japanese Agent for Solartron

As a result of a visit to Japan in November, 1960 by Mr. Denis Hendry, the Kyokuto Boeki Kaisha organization of Tokyo have been appointed exclusive agents for Solartron Electronic Group products in Japan.

The range of equipment covers oscilloscopes, digital voltmeters and associated equipments, together with analogue computers, data loggers, process response analysers and other systems equipment.

By agreement with the Japanese agents, one of their engineers, Mr. Yukio Anzai, has come to Solartron for three months intensive course in the various technical departments throughout the organization.

A.B. Metal Products Ltd.

Direct TV Replacements Ltd. have been appointed main distributors for A.B. Metal Products Ltd. in the area south of Nottingham and Stoke-on-Trent.

The range of components being handled includes carbon-track volume controls, wire-wound controls, constant impedance controls and rotary and push button switches.

Wholesale and quantity prices can be obtained from Direct TV Replacements Ltd.

Centre of Sound Opens

London's Centre of Sound opened on 29th June, 1961 at Archer Street, Piccadilly, W.1.

The Centre has been designed as a rendezvous for all concerned professionally, commercially or personally with sound reproduction or recording, and it is fully equipped for sound reinforcement and distribution throughout four floors.

The sound services which cover the building are operated from a Console housed in a control room on the first floor. The equipment, supplied by Magneta (BVC) Ltd., (one of the Goblin Group of companies), is to the specification of the Audio Industries Club Ltd., sponsors of the Centre and is based on a specially built console amplifier rack assembly, serving forty-one speakers.

Control, through the console, provides for microphone mixing, disc mixing and tape mixing and for monaural or stereophonic reproduction throughout the system.

The console equipment is designed for sound reinforcement and supply to speakers on all floors, providing three elements of sound: v.h.f. radio broadcast, recorded background music and sound, as required, from microphone inputs. Each floor is individually controlled.

As a special facility, a stereophonic output feeds speakers in the underground "Starlight" Bar and Theatre, where there are six microphone inputs, which can be patched in to the microphone mixer, so that volume and mixing can be centrally regulated.

Twin studio-type turntables are available from the console, to be used for stereo or monaural sound in the basement. The control room is also equipped for tape recording on the two machines supplied and these, too, may be used for stereophonic or monaural recording.

In addition to the sound system, timing equipment is also by Magneta, comprising wall clocks operated from a central master clock.

Meteorological Radar Chain for Middle East

The British Government has placed orders for 5 Decca windfinding radars and one weather radar, as a contribution under its programme of technical assistance to the regional countries of the Central Treaty Organization. These meteorological radars are for deployment along the air route Ankara, Tehran, Karachi, where there is a requirement for improved aviation weather services, and particularly for the introduction of modern instruments and equipment.

The type of windfinding radar being supplied is capable of measuring wind speed and direction up to the 100,000 feet level and will meet requirements, not only now but five to seven years hence when supersonic airliners are operating between 50 and 80 thousand feet.

This new and advanced equipment is a further development of the original Decca windfinding radar. Primary radar for the measurement of upper winds is being increasingly adopted by aviation weather services because of its ability to provide accurate information and the comparative cheapness of operating a chain of observing stations based on the use of this instrument.

Hughes International (U.K.) Ltd.—Scottish Agents

As from 1st July, Fraser Electronics & Communications Ltd., 1103 Argyle Street, Glasgow C.3, became sales agents for Hughes International (U.K.) Ltd., covering the sale of silicon and germanium semiconductor diodes and capacitors in Scotland.

This Company will be operating on behalf of the Hughes International Sales Office at Kershaw House, Great West Road, Hounslow, Middlesex and will maintain contact between this office, the manufacturing unit at Glenrothes in Fife and all customers in Scotland.

Israel Electronic Factory

A collective settlement in the north of Israel is reported from Jerusalem by Barclays Bank D.C.O. to have started operating a £100,000 factory for electronic parts. The machines are mostly of French origin.

Modern Factory for Dansette Products Ltd.

Dansette Products Ltd., have acquired a new modern factory in North-west London giving them an additional production area of 30,000 square feet. The acquisition of this factory will enable Dansette to further their programme of research and development into the midget transistor field. The factory is fully equipped with the most modern machinery for radio manufacture and will employ a large number of experienced workers. Dansette have purchased this factory out of company resources and it is hoped to increase production and turnover considerably.

Pye-Ling Ltd.—a New Company

On 10th July, 1961 the Vibration Division of W. Bryan Savage Ltd., a member of the Pye Group of Companies, became a separate company. This new Company will be known as Pye-Ling Ltd. and is a joint undertaking launched by Pye Ltd. of Cambridge and Ling Temco Electronics Inc., of Dallas, Texas, U.S.A.

NEW AMERICAN PRODUCTS

Del-Val Plastics Incorporated

Sub-miniature headers and shells: These are now available in sizes ranging from 0·550×0·130×0·125 in. to meet the most exacting high standards of packaging components, which enables a faster and more accurate assembling of components before encapsulating.

REC 165 *for further details.*

Universal Manufacturing Co. Incorporated

Toroidal Coil Winding Machines: Four new winding machines have recently been introduced—i.e. Model S which interchanges various sized toroidal winding heads and features a new type of completely transistorized electronic counter; Model LS-1 featuring the exclusive "Universal" interchangeability of various sized winding heads; Model L-7 handling #7 to #40 AWG and Model U-14 handling #7 to ±20 AWG.

REC 166 *for further details.*

Potter & Brumfield

4PDT Power Relay: Designated the PM series, this heavy-duty power relay is constructed for long life and dependability. It has a mechanical life in excess of 10 million operations at a maximum of two cycles per second with 50% dwell time. Rated load life is over 100,000 operations at a maximum of 14 cycles per minute with 50% dwell time.

REC 167 *for further details.*

PIC Design Corporation

Dual-purpose Shaft Extensions: Precisioned machined from #303 stainless steel, with clear passivated finish, in $\frac{1}{8}$ in., $\frac{3}{16}$ in. or $\frac{1}{4}$ in. shaft sizes, the extensions are furnished with same size male and female ends, or, in any combination of these sizes. Overall length of extension is $1\frac{5}{8}$ in., providing for one full inch of usable shaft surface. All diameters are concentric to 0·0005 of an inch.

REC 168 *for further details.*

Advanced Technology Laboratories

Bar Graph Display Oscilloscope: Named the ATL Profile Monitor Model 220, this instrument provides an accurate, easily interpreted, visual display of any phenomena measurable by an electrical output. Typically monitored are temperature, pressure, strain, and velocity. Selective vertical gain sensitivity, zero suppression control, automatic alarm system, and an electronic calibration grid line add to the versatility of the monitor, making it ideally suited to monitor petrol-chemical processes, power plant and wind tunnel parameters, and general laboratory experiments.

REC 169 *for further details.*

PERSONALITIES

Mr. R. Pearson

Bailey Meters & Controls Ltd. has recently appointed Mr. R. Pearson as its Sales Engineer for Scotland, Northumberland and part of County Durham. Mr. Pearson assumed his duties in June.

Pye Sales Staff

Pye Process Heating announce that, due to expansion, they have increased their Staff of Technical Sales Engineers.

Mr. R. P. Moore has been appointed the representative for the area South of London and the Southern Counties, and **Mr. R. Lapish** will cover the East Anglian area including Stamford, Wellingborough and Stevenage. **Mr. J. J. Tyrrell** will continue in the North London area and High Wycombe, with **Mr. J. A. Taylor** covering South Wales to Birmingham as far as the Yorks. and Lincs. border.

Specto Ltd. and Lentar Ltd. Appointments

Major J. F. E. Clarke, Chairman of Clarke & Smith Manufacturing Co. Ltd., of Wallington, Surrey, has now become Chairman of Specto Ltd., of Vale Road, Windsor, and of Lentar Ltd., the Specto associated company in the optical field.

Appointments of the following Specto Executive Directors have also been made: **E. M. Eldred,** M.I.E.E., M.Brit.I.R.E. (Managing); **L. C. Crook** (Deputy Managing); **D. J. Frost** (Sales); and **W. H. Ball** to Lentar Ltd. as Technical Director.

Mr. E. R. Thomas and Mr. B. A. Worswick

Mr. E. R. Thomas, who has been Managing Director of Elcontrol Ltd. since the Company was launched in 1948, has decided to retire from full-time executive duties and accordingly resigned as Managing Director. Mr. Thomas is remaining a Director of the Company and is retaining his financial interest in it.

Mr. B. A. Worswick, who has been Chief Engineer and Technical Director of the Company for the past eighteen months, has been appointed Managing Director.

Mr. R. F. G. Lea

Mr. R. F. G. Lea, Deputy Chairman and Joint Managing Director of CIBA (A.R.L.) Ltd., Duxford, Cambridge, has been appointed a Director of CIBA Clayton Ltd., Manchester.

Mr. H. R. Brooker

Mr. H. R. Brooker joined the Board of Johnson, Matthey & Co. Ltd. on the 15th June, 1961, as a joint Managing Director of the Company.

Mr. Brooker has hitherto been General Sales Manager and he will continue to be principally responsible for all the sales divisions of the Company.

Mr. M. Collins

Mr. Michael Collins of Advance Components Ltd., Hainault has been appointed Material Controller and Assistant to the General Manager. Mr. Collins, who was formerly the Company's Export Manager, has been with Advance Components since 1946. He served in the Royal Navy during the war and previous to this with Marconi's Wireless Telegraph Co. Ltd.

Mr. E. Moran

Mr. Eric Moran has been appointed by the Installation Equipment Group of The General Electric Co. Ltd. as the Group's Senior Representative to be based upon Leeds, Yorkshire.

Mr. Moran brings considerable experience to G.E.C. from his previous job as commercial engineer for Atlas Lighting Ltd. He is well known in Yorkshire for his lecturing upon Installation Technology at Leeds College of Technology, where he has taught candidates for the City and Guilds Electrical Installation Work Course during the last seven years.

Mr. F. T. Morse

The W. Bryan Savage Company has recently appointed Mr. F. T. Morse as Chief Application Engineer to the Vibration Division at their Stanmore Factory.

Mr. Morse will be responsible for all aspects concerned with the design and provision of the electronic systems the Company manufactures for the vibration testing of aircraft, missiles, electronic assemblies used in airborne equipment, and other forms of apparatus where the measurement of reliability under stringent environmental conditions is of importance.

Mr. C. R. Thompson

Mr. C. R. Thompson has recently been appointed an Executive Director of Pye T.V.T. Ltd., Cambridge. Mr. Thompson, who is 49, joined Pye in 1930. From 1941 to 1945 he was a civilian Technical Officer in the Royal Air Force, and he returned to Pye in 1949, since when he has been Service Manager of Pye T.V.T. Ltd.

Mr. J. W. Ryde

The General Electric Co. Ltd. announces with regret the death, on May 15th, 1961, at the age of 63, of John Walter Ryde, F.Inst.P., F.R.S., the Chief Scientist of the Hirst Research Centre of the Company, Wembley, Middlesex.

Mr. Ryde was educated at St. Paul's School and the City and Guilds Technical College, Finsbury, where he studied under Prof. Sylvanus Thompson, and subsequently served with the Royal Engineers in World

War I. He joined the newly-established Research Laboratories of The General Electric Co. Ltd. in 1919, directly from his war service, as a physicist, and was a leading member of the scientific staff of the Laboratories from the start.

His many and varied early research studies included pure spectroscopy, the gaseous electrical discharge and thermionics. His work on the scattering of light, first applied in the '20s to optical diffusing media in glasses, was developed by him during World War II to classic studies of the attenuation and the radar echoes produced by meteorological phenomena at centimetre wavelengths. He made significant contributions to the development of electrical discharge lamps, luminescent materials and optical projection systems. His researches in World War II included velocity modulation tubes and crystal valves for microwave mixer devices, together with work on the FIDO fog dispersal system. The design, in his leisure hours, of a pocket illumination chart for Service use was typical of him. It showed levels of illumination, by day and by night at various latitudes, and was used extensively in military operations.

Mr. Ryde was elected a Fellow of the Royal Society in 1948, "distinguished in his contributions to pure and applied physics". He was appointed Chief Physicist at the G.E.C. Research Laboratories in 1950 and Chief Scientist in 1953. During these recent years he has had overall responsibility for the programmes of pure scientific research of the establishment with particular interests in the fields of new materials, crystal growing and solid state physics.

His knowledge and interests were very broad. He was a Member of the Royal Institution of Great Britain since 1935 and Chairman of the Davy Faraday Laboratory Committee of the Institution since 1951. He has also served on the Board of Managers of the Institution and always took a great interest in its affairs. He was a Fellow of The Institute of Physics and of the Royal Astronomical Society, and a Member of the Geological Association, the Wiltshire Archaeological Society and the Athenaeum.

He earned the admiration and respect of eminent men both in this country and overseas. In all his work he displayed great ability and unfailing perseverance, together with brilliant insight and inspiration. His colleagues will always remember his patient readiness to discuss and assess the problems of the day and his helpful elucidation of critical experiments, often elegant in their simplicity, which he designed to solve them.

Sir Edward Playfair

Sir Edward Playfair, K.C.B., has been appointed Chairman of International Computers and Tabulators Ltd., with effect from the 1st August, on which date he was released from the post of Permanent Secretary to the Ministry of Defence.

NEW COMPONENTS

Continued from page 609

these being held in a simple, galvanised steel channel unit.

Any individual connector can be removed from this channel without dismantling the bank of connectors, simply by slackening a retaining end-clamp and sliding the connectors along the channel, turning the selected connector through 45° and lifting it clear. Thus, a connector assembly can be added to or reduced to suit varying requirements.

To achieve this quick assembly feature, the base of the porcelain block is chamferred. A press-stud hole in the top of the block allows a cover to be fitted, and there is a groove in the side of the block to hold an index card. This is a particularly useful feature for telephone applications.

The connector assembly is non-tracking and suitable for use in humid atmospheres. Three sizes, a telephone unit, a 30A unit and a 40A link unit, fit into a standard size of channel.

REC 139 *for further details.*

Geon Polyblend 503

British Geon Ltd. has issued a new Information Sheet on Geon Polyblend 503, a colloidal blend of p.v.c. and a butadiene/acrylonitrile rubber.

Polyblend 503 offers important advantages to both rubber and plastics processors. When used for conventional p.v.c. processing such as calendering or extrusion, Polyblend behaves as a thermoplastic in which the nitrile rubber acts a non-migratory plasticizer.

Previously it has been necessary to flux a nitrile/p.v.c. blend at temperatures in the region of 150° to 160°C (302° to 320°F) in order to achieve good ozone and sunlight resistance. This step is not necessary with Polyblend 503; additional nitrile rubber and curing ingredients can be blended in at normal process temperatures without loss of any physical properties.

The ratio of p.v.c. to nitrile rubber is 55:45. Straight p.v.c. resin of medium molecular weight is used and combined with rubber of medium-high acrylonitrile content (32—36%). Polyblend is supplied in the form of coarse amber granules.

REC 140 *for further details.*

Tetrodes for Linear Amplifiers

Eitel-McCullough Inc. have introduced, through Walmore Electronics Ltd., two new tetrodes to extend their range of valves specially produced for linear amplifiers/s.s.b. applications. These are designed to operate with zero grid drive power. The construction is of metal/ceramic and ring-type seals are used for screen, grid and cathode connections.

The 4CX3000A has 3 kW anode dissipation, and is of intermediate ratings between the well known 4CX1000A and 4CX5000A. As an r.f. linear amplifier a typical power output is 5·5 kW.

The 4CX10,000D is similar electrically to the 4CX5000A, but has a new design of air cooler. This improvement enables higher powers to be achieved. Alternatively the valve can be used at the same powers as the 4CX5000A with significant reductions in air-flow requirements.

Typical output as an r.f. linear amplifier is 15·9 kw; and a pair of valves in class AB1 audio amplifiers will give 30 kW.

REC 141 *for further details.*

3-Phase Miniature Circuit Breakers

The British Central Electrical Co. Ltd. announce substantial reductions in the prices of its Briticent 3-phase miniature circuit breakers.

Five models are available. A new type, enclosed in a waterproof, unbreakable, dustproof and anti-corrosive case has been added to the range. Types available are as follows:

Type "BD plug-in" for surface mounting, moulded in Bakelite with white top, black body and base. Top, bottom and rear "knockouts" are provided for cable entries. Size $3\frac{3}{8} \times 2 \times 2\frac{1}{4}$ in. Weight 11 oz. New price £2 10*s*. 4*d*. List.

Type "BD protected" (similar to Type BD plug-in). Housed in a sheet-steel case. Cable entries at top, bottom and rear, *via* waterproof plastic grommets. Size $3\frac{15}{16} \times 2\frac{3}{16} \times 2\frac{9}{16}$ in. Weight 11 oz. New price £2 19*s*. 8*d*. List.

Type "KD", for flush mounting, behind panels up to 11 s.w.g. Connections are made to flat, screw type terminals. Size $3\frac{1}{8} \times 1\frac{3}{4} \times 1\frac{9}{16}$ in. Weight 4 oz. New price £2 2*s*. 4*d*. List.

Type "KLP". As Type "KD" but with a polished duralumin plate for recess mounting. Plate size $3\frac{5}{16} \times 2\frac{2}{3}$ in. New price £2 5*s*.

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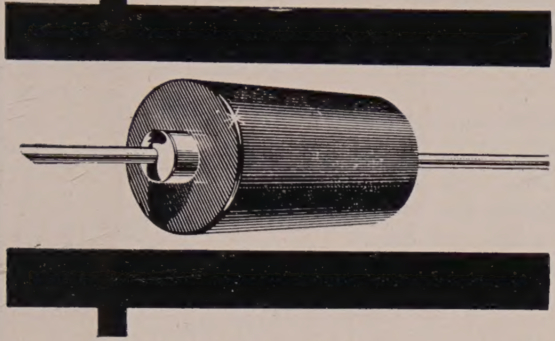
These miniature circuit breakers are basically three single-phase units, in one moulding, controlled by one trip and one reset button, and are suitable for protection of all 3-phase services, including motors up to 3 h.p. 440 V operation. They are available in 11 sizes, covering the total range 0·052—6 A, and each size is variable over pre-set ratings.

REC 142 *for further details.*

REC **25** for further information

ARCOL



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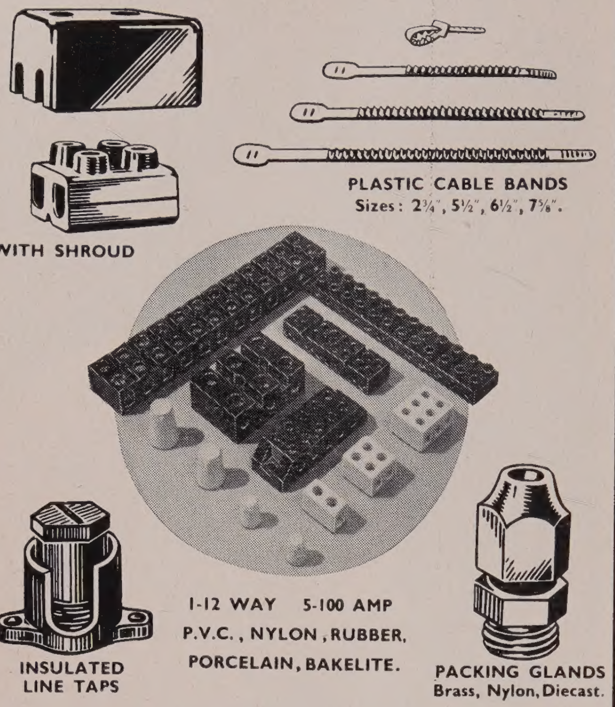

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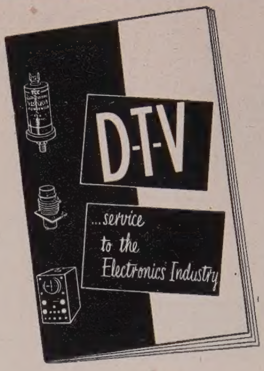
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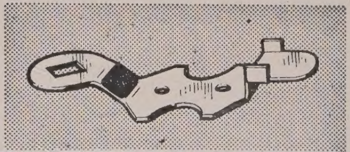

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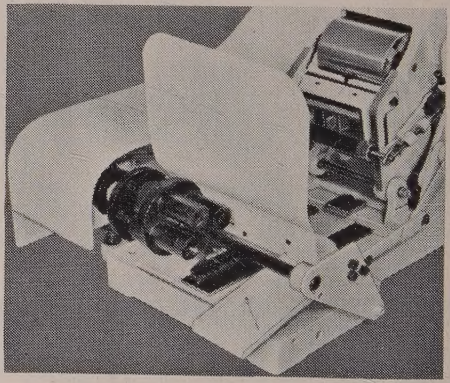

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